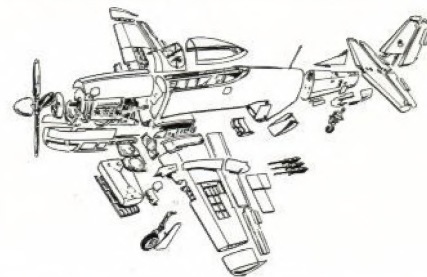


# WARBIRDTECH

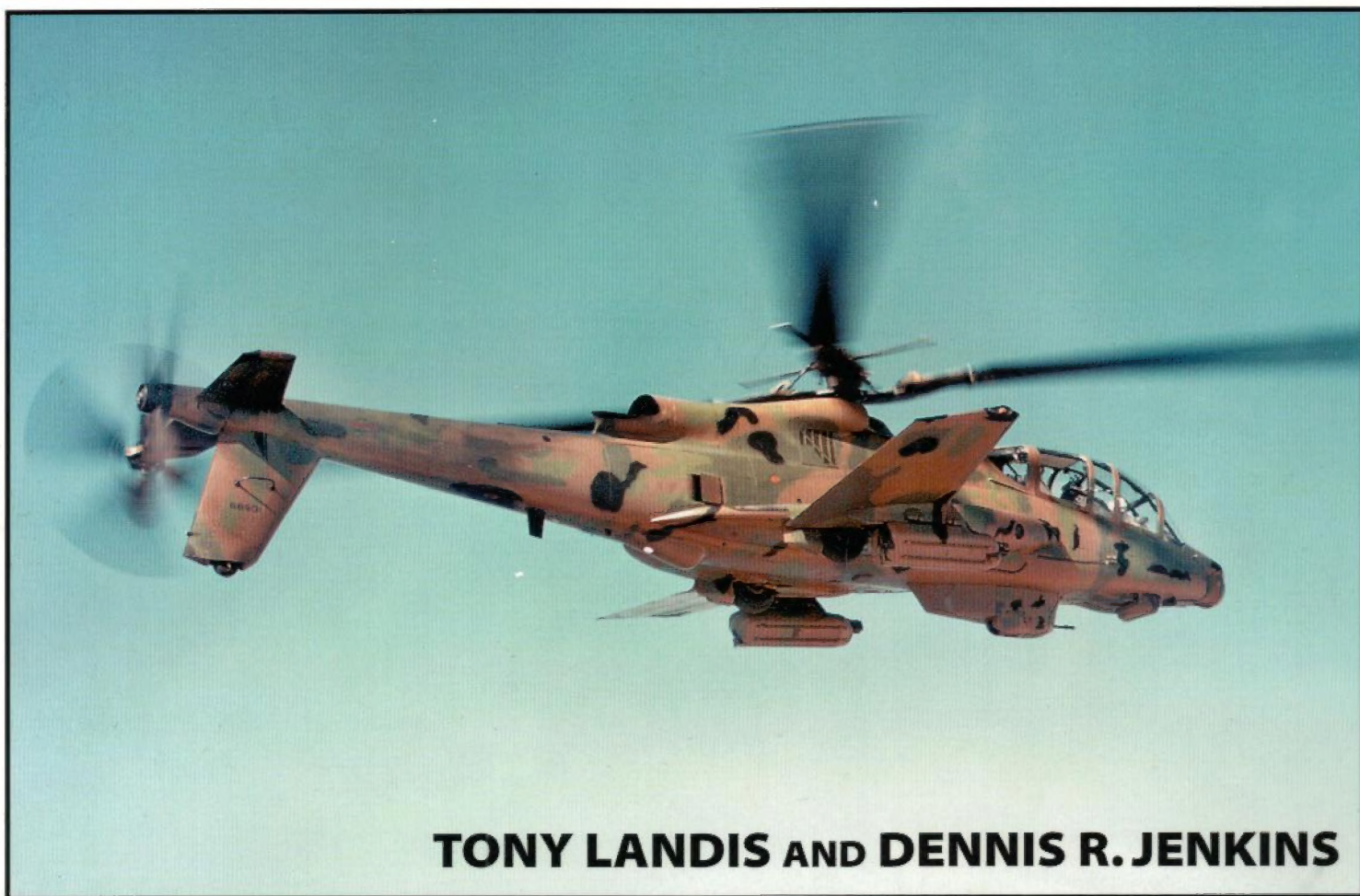
S E R I E S



## LOCKHEED

VOLUME 27

# AH-56A CHEYENNE

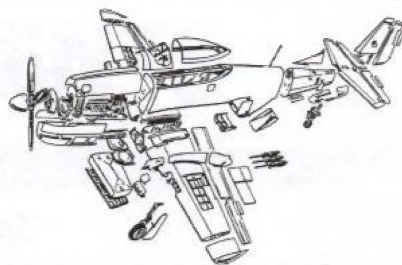


**TONY LANDIS AND DENNIS R. JENKINS**

- First Dedicated Gunship
- Weapons Systems Details
- Cockpit Photos
- Hingeless Rotor Description
- Extensive Testing Program
- Propulsion System Details

# WARBIRDTECH

S E R I E S



VOLUME 27

LOCKHEED

# AH-56A CHEYENNE

BY TONY LANDIS AND DENNIS R. JENKINS

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*Designed by Dennis R. Jenkins*

*Printed in the United States of America*

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Front Cover: *The sixth Cheyenne (1006; 66-8831) was painted in this three-tone tactical camouflage scheme late in the flight test program. The aircraft is carrying three-tube TOW missile launchers on the inboard pylons. (San Diego Aerospace Museum Collection)*

Back Cover (Left Top): *Ship #1006 (66-8831) flying low over Yuma Proving Grounds. (Lockheed)*

Back Cover (Right Top): *Sunset during a test flight to 22,500 feet over Castle Dome, at Yuma, Arizona. (Lockheed via the Don Segner Collection)*

Back Cover (Lower): *The Advanced Mechanical Control System (AMCS) was the key to solving the last of the Cheyenne's controllability deficiencies. The AMCS moved the gyro from the top of the rotor mast to under the transmission, and is easily identifiable in photos because of this. (Don Segner Collection)*

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# PREFACE

## AND THE THANKS GO TO ...

**D**uring the 1960s, the Army embarked on a variety of projects to develop high-tech weapons. Many of the projects were small, but two were major development efforts. The MBT-70 main battle tank was one. This remarkable vehicle would have revolutionized the battlefield, if only it had worked. The technology of the 1960s was not quite up to the advancements envisioned by its German and American designers. Ultimately much of the technology and capabilities of the MBT-70 were incorporated into the very successful M-1 Abrams and German Leopard 2 tanks.

The AH-56A Cheyenne was the other major project. The Cheyenne would also have revolutionized the battlefield, if only the politicians had let it. Although the aircraft suffered from numerous technical problems during its development, none were serious enough to cause its ultimate failure. That would be the job of the politicians, both directly and indirectly. The Cheyenne was one of the victims of Robert McNamara's Total Procurement Policy contracting scheme that also caused many problems for the F-111 and C-5. But unlike the Air Force, the Army had no real experience dealing with either the Pentagon nor defense contractors; and therefore was not

equipped to deal with the budgetary, scheduling, political, and public relations problems brought on by McNamara's bizarre concept for weapons development.

The five years the Army spent developing Cheyenne was not totally wasted. Many of the fire control and navigation concepts developed for the AH-56A found their way in the AH-64 Apache, which at least in theory, replaced Cheyenne. But the Apache is not the son-of-Cheyenne, as is often claimed – it is a helicopter. A decent helicopter to be sure, but a helicopter nevertheless. Cheyenne was much more; almost an airplane, but with all the benefits of having a rotary wing to use when the pilot needed it most. At almost 250 knots, the Cheyenne could run rings around any helicopter in existence – then or now.

Instead, Cheyenne was cancelled, just as most of its more serious problems were finally being solved.

With it went Lockheed's future as a rotary-wing aircraft manufacturer, and several hundred million dollars of taxpayer money. And thankfully, the last of McNamara's total package procurement policy.

Special thanks go to Denny Lombard at Lockheed Martin Skunk Works for going above and beyond to obtain a large percentage of the photos used here. Lockheed test pilot Don Segner generously gave his time as well as materials from his personal collection, and Floyd Dominick answered many questions on development and flight test. Thanks also go to Tony Accurso, Gary Bender, Ron Girouard, Matt Graham, Marty Isham, A. J. Lutz (San Diego Aerospace Museum archives), Yancy Mailes, Steve Maxham (U. S. Army Aviation Museum), Daryl Niewald, Heidi Page, Mick Roth, and Jim Upton (flight test engineer on 1005). Thanks also go to the publisher, Dave Arnold, for allowing us to try a helicopter book as part of the *WarbirdTech Series*.

*The seventh Cheyenne (1007; 66-8832) over Yuma Proving Grounds in October 1970. Triple TOW missile launchers are on the inner pylons and 2.75 FFARs on the outer pylons. (Lockheed)*



# HELICOPTER AERODYNAMICS

## BEATING THE AIR INTO SUBMISSION

**H**elicopters are not like airplanes. One of the common jokes around helicopter people is that no, they cannot fly; they just beat the air into submission. That the first helicopters flew at almost the same time as their fixed-wing counterparts is merely a coincidence. That it took three decades longer to produce an even somewhat practical design shows the additional complexities that had to be overcome. For those not familiar with how helicopters fly, a short tutorial and some history follows.

On a classic helicopter, all lift is generated by the main rotor. Compared to the wing of an airplane, the rotor of most helicopters is, at best, only loosely attached to the aircraft. While this is the key to the unique capabilities of the helicopter, it also brings with it some unique stability and control issues.

When Juan de la Cierva began developing his autogyro in the early 1920s, the first thing he did was build a rubber-band-powered model of the concept. The model flew surprisingly well, so Cierva was encouraged to build a full-scale prototype. Autogyros are not helicopters; they cannot take off vertically, hover, or fly sideways. Instead they use an unpowered main rotor that turns when air rushes over it. This means they need forward airspeed, provided by a conventional engine and propeller, in order to turn the rotor. Because of this, autogyros take off much like conventional aircraft, using a short ground run.<sup>1</sup>

Nevertheless, autogyros and helicopters share a great deal in common, particularly the design and characteristics surrounding the operation of the main rotor. As Cierva was beginning to build speed on his first ground run, his autogyro

suddenly rolled over, thrashing the rotor blades into small wooden fragments. Believing this to be a quirk, Cierva rebuilt the aircraft and tried again, with the same results.

Cierva could not understand why his autogyro was rolling over as it built speed; the rubber-band powered model had not exhibited any tendency to roll. After much thought, the difference between the two machines became evident. As is often the case, it was one of scaling; in this case the difference between rigid blades and flexible blades.

On the full-scale autogyro, Cierva had braced the main rotor blades with struts and wires, much like airplane wings of the era. This was necessary to ensure the long, slim blades were structurally sound. But the model had used flexible rattan blades, adequate in such a small scale.



*An early Cierva autogyro. The main rotor provided lift, but not propulsive power, which was provided by the engine and propeller in the nose. (Kadel and Herbert News Service via the San Diego Aerospace Museum Collection)*

As the rigidly-braced autogyro began its takeoff run, the airspeed seen by the blades changed during the period of each revolution. On the advancing side (when the blade was traveling towards the nose of the aircraft), the airspeed was higher than on the retreating side (where the blade was heading towards the tail). Since each blade had the same pitch setting, and therefore the same angle-of-attack, the difference in velocity produced more lift on the advancing side – generating an imbalance that rolled the aircraft over.

But on the model, the flexible rattan blades could bend up and down. Thus the advancing blade, which had more lift, began to flap upward. As it did, the effective

angle-of-attack was reduced, along with the amount of lift generated. The retreating blade was undergoing similar dynamics, except it was flapping downward as it rotated toward the tail. This increased that blade's angle-of-attack, causing it generate more lift. Although the efficiency (amount of lift) of this type of rotor was less than optimum, the overall result was a useable device that provided roughly equal lift on both sides of the aircraft.<sup>2</sup>

Cierva figured that the simplest solution to this problem was to install mechanical hinges on his full-scale rotor that would allow the blades to flap up and down in response to the changing lift, just as the rattan blades had bent. In

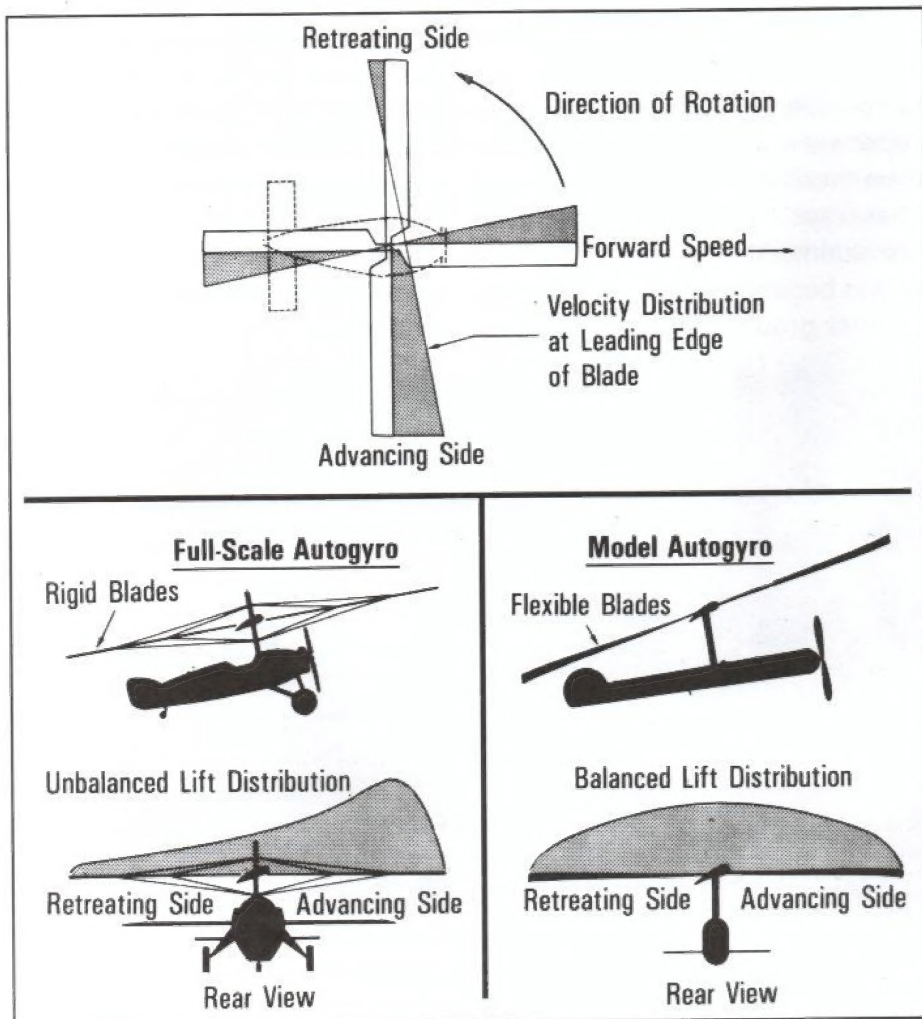
flight, the blades were kept extended by centrifugal forces, and coned slightly upward by lift. With this breakthrough, Cierva was finally able to fly his autogyro, and provided a legacy used by most helicopters for the next half century.

The invention of the flapping hinge, however, did not provide the answer to all the problems. Cierva soon noticed that the blades on his autogyro were encountering a high rate of structural failure resulting from drag and inertia loads during each rotor revolution.<sup>3</sup>

The answer, again, came from a hinge. This time, Cierva installed a "drag hinge" that allowed each blade to move back and forth slightly in the rotor plane without generating excessive forces at the root attachment point. These are now known as lead-lag hinges, and in conjunction with flapping hinges, produced the fully articulated rotor systems in common use today.<sup>4</sup>

One of the major advances on the Cheyenne, as we will see, was that it did away with these hinges. Commonly called "rigid rotors," in reality they are anything but rigid. The blades are still allowed to flap, although perhaps not quite as much, but they do so by deforming their own flexible structure, not through a hinge. In essence, we have managed to build full-scale blades that behave the same as the rattan blades on Cierva's model.

*This illustration from Practical Helicopter Aerodynamics graphically illustrates the differences between Cierva's model autogyro and his first full-scale aircraft. (PJS Publications)*



## Rotor Control

Exactly how to control his autogyro presented another challenge to Cierva. On most early autogyros, the rotor was simply a lifting device and was allowed to flap as necessary in order to balance the lifting forces. Roll was controlled by ailerons on stub wings, and pitch was controlled by a conventional elevator, just like on airplanes. Neither method, however, was particularly effective at low speed.

To overcome this, Cierva developed a means of obtaining direct control over the lifting forces by tilting the entire rotor plane by gimbaling the shaft. With this scheme, pitch and roll control were generated by tilting the rotor thrust vector to provide a moment with respect to the aircraft's center of gravity.

Titling the entire rotor shaft was satisfactory for small autogyros, but as the aircraft became larger the force necessary to accomplish this became too great. And once the rotor became powered, as in a helicopter, the task became hopeless. At this point the concept of cyclic pitch control was introduced, and is used almost universally today.

In this system, the pilot cyclically changes the pitch of each individual rotor blade by tilting a device known as a swashplate. In opera-

tion, if the swashplate is perpendicular to the rotor shaft, the blade angle is constant. But if the swashplate is tilted, each blade will go through one complete pitch change during each revolution.

If the pilot pushes the stick forward, the swashplate is tilted forward. As the individual rotor blades pass on the advancing side, their pitch is decreased; on the retreating side the pitch is increased. Because of the effect of gyroscopic precession, the maximum downward deflection of the blades is forward and the maximum upward deflection is at the rear, causing the entire rotor plane to tilt forward. A similar analysis can be applied for any other directional displacement of the cyclic control stick.

So the main rotor provides two types of control movements. The rotor is able to control the amount of lift being provided by changing the pitch of all the blades at the same time, or "collectively." During

this change, the main rotor RPM must be maintained at approximately the same rate, requiring a change in the throttle setting of the engine. To move the helicopter into forward, sideward, or backward flight from a hover requires a change in the rotor's plane of rotation, accomplished by changing the pitch of each blade individually, or "cyclically."

On a helicopter the rotor is powered, presenting more problems. Any large object that is turning produces torque. On a helicopter the rotor turning creates a tendency for the fuselage to rotate in the opposite direction. This effect is countered on single-rotor helicopters by the use of a small anti-torque rotor (often called a tail rotor). The pitch on the anti-torque rotor's blades is increased or decreased as needed to maintain the desired direction of flight. In twin or tandem rotor helicopters, the rotor systems rotate in opposite directions, effectively canceling out the effects of torque.<sup>5</sup>

*A late-model Cierva autogyro. Like all autogyros, Cierva's creations were not capable of taking off vertically, nor hovering, since they needed forward airspeed to turn the main rotor. They could, however, land in a remarkably short distance.*

(Acme News Pictures via the San Diego Aerospace Museum Collection)



## Cockpit Controls

A conventional airplane contains three basic sets of cockpit controls: a control stick, rudder pedals, and a throttle. A helicopter contains four: a cyclic stick, a collective lever, anti-torque pedals, and a throttle. This is not as bad as it may seem since on helicopters, especially turbine-powered ones, the throttle is generally automatically adjusted after takeoff.

The cyclic stick is held in the right hand and causes the helicopter to pitch or roll by tilting the swashplate. The collective lever, held in the left hand, changes the pitch on all the blades simultaneously by raising and lowering the entire swashplate (instead of tilting it), producing more or less thrust. Usually the throttle is a grip-type control located on the end of the collective. The anti-torque pedals serve much the same purpose as the rudder pedals on an airplane, except on a helicopter they provide directional control in a hover by adjusting the collective pitch of the anti-torque rotor blades. In straight flight, the anti-torque rotor thrusts in the opposite direction of main rotor rotation just enough to counteract the torque. To turn in the direction of the

main rotor's rotation, the thrust of the anti-torque rotor is reduced; to turn opposing the main rotor, the thrust is increased. The anti-torque pedals move in the same manner as in an airplane – push the right pedal to turn to the right; push the left pedal to turn to the left.



*A Cierva autogyro (G-EBYY) at Le Bourget Field in Paris after completing a trip across the English Channel from Croyden, England on 25 September 1928. The aircraft crashed several days later, injuring its occupants. (P&A Photos via the San Diego Aerospace Museum Collection)*

<sup>1</sup> Prouty, Ray W., *Practical Helicopter Aerodynamics*, PJS Publications, Inc., Peoria, IL, 1982, pp. 21-25. <sup>2</sup> Carey, Keith, *The Helicopter*, TAB Books, Blue Ridge Summit, PA, 1986, pp. 11-12. <sup>3</sup> Prouty, Ray W., *Practical Helicopter Aerodynamics*, PJS Publications, Inc., Peoria, IL, 1982, pp. 21-25. <sup>4</sup> For various dynamic reasons, two-bladed rotors do not need to use lead-lag hinges, and the flapping hinges are usually configured as a single teetering hinge that allows the two blades to flap as a single unit. <sup>5</sup> Carey, Keith, *The Helicopter*, TAB Books, Blue Ridge Summit, PA, 1986, p. 13.

# THE BEGINNINGS

## HELICOPTERS COME OF AGE

**L**eonardo da Vinci is generally credited with sketching and describing a helicopter-like device in 1483, although the ancient Chinese had played for centuries with a hand-spun toy that rose upward when revolved rapidly. Leonardo's design, like many others to follow, may have worked in theory but would have been impractical in full-sized form. Many extraordinary models were developed by an ever increasing number of great thinkers, but all the pioneers were missing two essentials: a true understanding of the nature of lift, and an adequate engine. Despite Leonardo's genius, it would take another 450 years before the first experimental helicopter would take flight. Like the airplane, the helicopter required a lightweight power source; the great break-

through came at the end of the nineteenth century with the invention of the internal combustion engine. It was then the first of many great problems came to light.<sup>1</sup>

Brothers Louis and Jacques Breguet, in association with Professor Charles Richet, built Gyroplane No. 1 during 1907, only four years after the first flight of the Wright Brothers. The aircraft was constructed of steel tubing and used four eight-bladed rotors, for a total of 32 lifting surfaces powered by a single 40-hp Antoinette piston engine. On 19 September,<sup>2</sup> a Frenchman named Volumord piloted the machine some two inches off the ground. The aircraft was extremely unstable and needed to be stabilized by four helpers on the ground – therefore it is generally not credit-

ed as being the first true helicopter flight, even though the helpers did not contribute any lift.<sup>3</sup>

On 13 November 1907, the French pioneer Paul Cornu lifted a twin-rotor helicopter powered by a single 24-hp Antoinette into the air entirely without assistance from the ground. The flight at Coquain-Villiers, near Lisieux, lasted only twenty seconds and achieved an altitude of 1-foot, but was still a milestone in the evolution of the helicopter. This aircraft was also highly unstable, eventually causing Cornu to abandon further development.

After that, several models were produced by other designers, but there were no great advances until 1924 when another French pioneer, Etienne Oehmichen, became



*A Breguet helicopter was demonstrated to the U.S. Army Air Corps at Wright Field during 1922. This was a much developed version of the aircraft that first flew in 1907, although it was still very unstable. Note the "helpers" hanging onto the aircraft below the rotors to assist in balancing it. (San Diego Aerospace Museum Collection)*

the first to fly a helicopter for a distance of a kilometer. The historic flight took 7 minutes and 40 seconds. Around the same time, Juan de la Cierva began experimenting with his autogyros.

Interestingly, Cierva's first design used a hingeless rotor, something that will be important later in this story. Unfortunately, the hingeless rotor was something technology of the day was not ready for, and aerodynamic asymmetry caused Cierva's machine to roll over, prompting him to introduce the flapping hinges that would become a hallmark of helicopter design.<sup>4</sup>

It was not until 1935 that a helicopter constructed by Louis Breguet and Rene Dorand in France routinely achieved flights of sustained duration. By 1936, solutions to many of the problems had been found, and the German Focke-Achgelis Fa 61<sup>5</sup> was probably the first truly practical helicopter. The

Fa 61 used a fuselage from the Fw 44 Stieglitz trainer, with the forward propeller cut-down to little more than a cooling fan for the engine. Two large rotors were mounted on outriggers where the wing should have been. Flugkapitän Hanna Reitsch made the first free flight in the Fa 61 on 26 June 1936, remaining airborne for 45 seconds. On 10 May 1937 the aircraft made the first successful autorotation. During February 1938, Reitsch flew the Fa 61 indoors, in the *Deutschlandhalle* in Berlin, on 14 consecutive nights. Later, the helicopter was flown from Bremen to Berlin at an average speed of 68 mph, a record for the day.

But the future success of rotary-wing aviation was due almost entirely to Igor Sikorsky, a Russian who had fled from the Bolshevik Revolution in 1917, eventually settling in the United States. In 1938, Sikorsky was the engineering manager of the Vought-Sikorsky

Division of the United Aircraft Corporation, and he received permission to revive his work on experimental helicopters.

Sikorsky designed the VS-300 during the spring of 1939 and constructed the first prototype that summer. The VS-300 had a 75-hp Franklin 4-cylinder engine, and was constructed primarily of heavy gauge welded steel tubes with no external skin. The first vertical take-off took place on 14 September 1939 with Sikorsky, as the pilot, wearing his soon to be legendary Homburg. Only a few company engineers and mechanics were there to see the wheels of the vibration-racked machine go as far from the ground as its short tethers would allow.

The first untethered flight took place on 13 May 1940, with Sikorsky again at the controls. The aircraft would go through at least 18 distinct configuration changes over the next six months. The resulting VS-300A could climb vertically, and fly sideways and backward with reasonable stability and safety. What it could not do was fly forward; it would take until early 1941 before Sikorsky figured out this minor annoyance.

On 6 May 1941, in front of the press and other witnesses, the VS-300A broke the world endurance record previously held by the Fa 61; it hovered motionless for 1 hour 32 minutes 26.1 seconds. Testing of the VS-300A continued throughout the following year, and Captain Franklin Gregory soon became the first U.S. military pilot to fly a helicopter.

During 1941, the U.S. Army Air Corps awarded a contract to Sikorsky Aircraft to build the XR-4 heli-



*Igor Sikorsky, wearing his trademark Homburg, at the controls of the VS-300A. The aircraft had just set a world endurance record of 1 hour and 32.5 minutes. (Sikorsky via the San Diego Aerospace Museum Collection)*

copter, essentially a developed version of the VS-300 known as the VS-316A. This aircraft would gain the distinction of being the first mass-produced helicopter. Like the VS-300, the fuselage was constructed of welded steel tubing, but it was now fully enclosed by fabric except for a small area around the tail rotor. The two-place cockpit was covered by a plexiglass canopy. The VS-316A was almost twice as large as the VS-300, and made its first flight on 14 January 1942. Beginning on 18 May 1942 it made a 761-mile, five-day, trip from Bridgeport, Connecticut, to Wright Field, Ohio – a helicopter record.<sup>6</sup>

Approximately 100 R-4s were built for the U.S. Army, with 45 of them being transferred to the Royal Air Force as the Hoverfly 1. The R-4s began to replace the Cierva Rota autogyros with the British Royal Air Force No. 529 Squadron during 1944. Additional VS-316As saw service with the U.S. Navy and Coast Guard as the HNS-1. Although these and other helicopters saw limited operations during World

War II, they could be considered more of a novelty than anything else and did not contribute any militarily useful service.

Many advancements in helicopter design were made after the war, and the Sikorsky S-55 became the first commercial transport helicopter to be certificated by the civilian authorities (CAA in 1950; FAA in 1951). The Korean War saw the first widespread use of the helicopter in combat. As depicted on the television show *M\*A\*S\*H* every week, the Army used Bell OH-13 Sioux<sup>7</sup> (military version of

the Model 47) helicopters to carry the most seriously wounded from the front lines to hospitals for treatment. High priority passengers and light cargo were also flown by helicopters, although the limited payload capacity of the early piston-engine aircraft presented a serious handicap. Perhaps the most militarily useful application of the helicopter was as an artillery spotter. Much like observation balloons from World War I, helicopters were used to spot the fall of artillery shells, reporting back by radio so gunners could adjust their aim. However, the heli-



*An intermediate version of the VS-300 with Igor Sikorsky at the controls. The sign on the rear fuselage reads "VOUGHT-SIKORSKY VS-300, Stratford, Connecticut." (Sikorsky via the San Diego Aerospace Museum Collection)*



*The Vertol H-21 Shawnee was the major troop and utility helicopter during the early stages of the conflict in Southeast Asia. This is an H-21C photographed on 23 May 1957. Like most subsequent Vertol (Boeing) helicopters, the Shawnee was a tandem design that used two main rotors rotating in opposite directions to counteract the torque effects. (Boeing-Vertol)*



*A VS-316A (NX28996) being flown by Igor Sikorsky on 16 March 1942. This aircraft was generally similar to the VS-300 but had a completely enclosed fuselage. Note that the right wheel (white circle) has fallen off, and almost hit the person on the ground. (Sikorsky via the San Diego Aerospace Museum Collection)*

copter proved to be exceptionally vulnerable to enemy fire, and was generally kept away from direct contact with the enemy.

By the end of the 1950s, the Sikorsky H-19 Chickasaw, Piasecki (Vertol) H-21 Shawnee, and Sikorsky H-34 Choctaw were providing the U.S. Army with the first tangible proof that helicopters could be integrated within ground forces. However, their primary role was still providing high-value (but light-weight) cargo services, limited troop transport, and the evacuation of wounded troops from the battlefield. Although a few helicopters had been fitted with 0.30- or 0.50-caliber machine guns for self-defense, there had not been any serious consideration of using the helicopter as a weapon.

Nevertheless, during the summer of 1956, Colonel Jay Vanderpool began to experiment with the concept of armed helicopters as weapons. Brigadier General Carl Hutton, commander of the Army's aviation training units at Fort Rucker, Alabama, was an early believer in the concept, and provided limited encouragement to Vanderpool. What Hutton could not provide, however, was funding. The early experiments were conducted using whatever assets could be begged or borrowed from the various school units at Fort Rucker.<sup>8</sup>

Within a year, Vanderpool had assembled a small fleet of armed helicopters, although none were in any sense combat-ready. The majority of the aircraft were H-19s, H-21s, or H-34s fitted with small-caliber machine guns or grenade launchers. Soon, a special tactics organization named Sky-Cav (Sky Calvary) was informally established



*The Sikorsky H-34 Choctaw was used extensively by all the military services. This was a military derivative of the Sikorsky S-58, which had become the first commercial transport helicopter certificated by the FAA. (U.S. Army)*



*Colonel Jay Vanderpool operated a rag-tag fleet of armed helicopters at Fort Rucker in the late 1950s. Included was this H-34 modified to carry unguided rockets along the side of the fuselage. This was long before the now-standard pod configuration had been developed. (U.S. Army)*



*An early attempt at providing an anti-armor capability for helicopters was the SS11 anti-tank guided missile, circa 1964-65. This program was not extensively fielded, and was eventually replaced by TOW. (U.S. Army)*



*One of the early configurations for carrying unguided rockets on the Huey was this 24-tube launcher that was very similar to the one carried on the H-34. (U.S. Army)*

*As fielded in Southeast Asia, armed versions of the turbine-powered Bell Iroquois, such as this UH-1C, were adequate to escort the original piston-powered CH-21s and CH-34s. Note the rocket pod and 7.62-mm minigun hung on the side. (U.S. Army)*

at Fort Rucker to experiment with tactics using the new weapons. The most immediately-useful role the Sky-Cav could devise was that of an armed reconnaissance force. Apparently the experiments were successful; in the summer of 1957 the unit was official organized as the Aerial Combat Reconnaissance Platoon. Within a year, the unit had been redesignated the 7292nd Aerial Combat Reconnaissance Company (Provisional). The role of the helicopter in the modern Army had begun.<sup>9</sup>



Although progress was being made, it would take the development of lightweight turbine engines for the helicopter to finally realize its true potential. The first turbine-powered helicopter was the Kaman K-225, although the Aérospatiale Alouette from 1955 probably had a greater historical impact. The turbine engine offered a tremendous increase in available power from a smaller and lighter package, although the first models were extremely thirsty. This posed somewhat less of a problem for helicopters than for early jet aircraft simply because helicopters were not expected to travel far in the first place, and they could land just about anywhere to refuel.

### Southeast Asia

But the helicopter's widespread success is irrevocably linked to the conflict in Southeast Asia. It was unlikely anybody suspected this when the development of the Bell Model 204 began in 1960. Destined to be the first turbine-powered helicopter to equip U.S. Army units, the 204 began life when the Army identified a requirement for a replacement for the OH-13 as a casualty evacuation (casevac) aircraft, with a secondary utility airlift mission. Initially designated H-40, the Iroquois made its maiden flight in October 1956, and a small number of redesignated HU-1As were ordered into production.<sup>10</sup>

Only 200 HU-1As were built before production switched to the slightly improved HU-1B. The new "unified" aircraft designation system of 1962 saw the Iroquois again redesignated, this time as UH-1A and UH-1B, respectively. Over 1,000 UH-1Bs were manufactured, followed by another 800 UH-1Cs. The helicopter

was becoming a mainstay of the U.S. Army. Eventually, more Hueys would be built than any other aircraft except the Soviet An-2 biplane transport.<sup>11</sup>

It is not surprising, therefore, that the early Iroquois soon found themselves in the jungles in Southeast Asia. The first arrived in early 1962, although the quantity

involved remained fairly small until the summer of 1964 when U.S. involvement in Vietnam began to increase significantly. Almost from the beginning, troops armed their UH-1s, usually with machine guns mounted in the rear doors, and occasionally with 2.75-inch rocket pods bolted to the landing skids. Although not extensive, this limited firepower provided critical cover for



*This photo demonstrates the size difference between the CH-47A and a UH-1B. Note the machine gun and gunner on the open rear ramp of the CH-47. Boeing continues to build CH-47Ds in the year 2000. (U.S. Army)*



*The turbine-powered CH-47A Chinook quickly replaced the piston-powered H-21s and H-34s in Vietnam beginning in 1963. The Chinook was a good 50 knots faster than the UH-1 Iroquois – a situation that prompted the Army to begin looking for a dedicated escort helicopter that could keep up with the CH-47. (U.S. Army)*

troops while they embarked or disembarked the CH-21s or other UH-1s on the battlefield.<sup>12</sup>

By 1964 there were over 200 UH-1s in Southeast Asia; that number would increase to over 2,500 at any one time later in the war. The Iroquois allowed Army units to operate in totally new ways. Instead of the infantry marching or being trucked to the battle, they were flown; armed Hueys escorted the “slicks” that carried the troops. But a

flaw existed in the new tactic; instead of holding onto hard-won ground, the infantry was often airlifted out immediately after the battle. The North Vietnamese simply reclaimed the territory after the Americans had left. Nonetheless, the new tactic quickly became the mainstay of the U.S. Army in Vietnam. Tragically, by the end of the war, 1,213 UH-1s would be lost to hostile action, and a further 1,380 to other operational causes (accidents, etc.).<sup>12</sup>

Although the armed versions of the UH-1s were not an ideal escort, they were adequate early in the war. They were as fast as the troop-carrying Hueys, and much faster than the older CH-21s that still formed the bulk of the helicopter force. And the North Vietnamese and Viet Cong had not gotten terribly sophisticated with their defenses. Yet.

Beginning in 1963 and 1964, the CH-21s were replaced by the new Boeing-Vertol CH-47A Chinook. Because of its large size and high speed, the Chinook quickly became the primary troop carrier. This presented a problem for the escorts, however – the CH-47 was almost 50 mph faster than the UH-1. It was obviously desirable to take advantage of the extra speed available to the Chinook since it reduced the amount of time the helicopter was vulnerable to the enemy. However, when operating at maximum speed, the Chinooks had to go in unescorted; the armed UH-1s simply could not keep up. Alternately, the Chinooks could slow down and allow the Iroquois to escort them, but this lengthened their exposure.

Neither alternative was ideal.<sup>14</sup>

<sup>1</sup> Since a history of helicopters is not the primary aim of this book, the brief history that follows is somewhat unbalanced and imprecise. There are several interesting histories on book shelves, including *The Helicopter* by Keith Carey that provides a good deal of this summary material. <sup>2</sup> Carey uses 19 September 1907, but other references say this occurred on 24 August. <sup>3</sup> Carey, Keith, *The Helicopter*, TAB Books, Blue Ridge Summit, PA, 1986, p. 11. <sup>4</sup> Prouty, Ray W. and Yackle, Al R., *The Lockheed AH-56 Cheyenne – Lessons Learned*, AIAA Document 92-4278, presented at the AIAA Aircraft Design Systems Meeting, 24-26 August 1992, Hilton Head, S.C., p. 1. <sup>5</sup> Some sources list this as the Focke-Wolfe Fw 61. But even DASA, the modern-day descendant of all the German aerospace companies, lists the design as the Fa 61. <sup>6</sup> The five-day trip consisted of just over 16 flight hours. <sup>7</sup> With very few exceptions, U.S. Army helicopters are named after American Indian tribes. The popular name *Huey* is not the official moniker of the UH-1-series of helicopters – *Iroquois* is. The *Huey* name reportedly was derived from the original designation (HU-1). The most notable exception to the Indian naming convention is the AH-1 *Cobra*, which is a variant of the UH-1-series. <sup>8</sup> Peacock, Lindsay, *AH-1 HueyCobra*, Osprey Combat Aircraft Series No. 9, Osprey Publishing, London, 1987, p. 4. <sup>9</sup> *Ibid*, p. 5. <sup>10</sup> *Ibid*, p. 5. <sup>11</sup> Carey, Keith, *The Helicopter*, TAB Books, Blue Ridge Summit, PA, 1986, p. 36. <sup>12</sup> Peacock, Lindsay, *AH-1 HueyCobra*, Osprey Combat Aircraft Series No. 9, Osprey Publishing, London, 1987, p. 5. <sup>13</sup> Hewson, Robert, *Beyond the Frontiers: Lockheed AH-56 Cheyenne – The Lost Tribe, Wings of Fame*, Vol. 14, Airtime Publishing Inc., 1999, p. 137. <sup>14</sup> Peacock, Lindsay, *AH-1 HueyCobra*, Osprey Combat Aircraft Series No. 9, Osprey Publishing, London, 1987, p. 6.

# A BITTER ARGUMENT

## THE ARMY VERSUS THE AIR FORCE

**T**he Army realized that it needed a new type of aircraft to escort troop helicopters. The lesson had actually been learned in Korea, when the medical evacuation helicopters had come under attack while landing at the front lines; but like many other lessons, it was forgotten during the relatively peaceful ten years between the wars. At the same time, the infantry needed dedicated tactical air power, much like that which had been available in World War II when the Army controlled both the air and the ground forces. In the new scheme of things, the Air Force was responsible for close air support (CAS). But the mission was not glamorous, and the Air Force did not embrace it. In fact, none of the Air Force's fighters were equipped to provide CAS at all; the F-100s and F-105s proved to be capable fighter-bombers, but against large well-defined targets,

not small troop concentrations near to friendly forces.

The Republic F-105 Thunderchief typified a great many trends in fighter design. It was much larger and more complex than its predecessors, and cost a great deal more to acquire and maintain. The F-105 could operate only from well-equipped bases, and although its range was excellent at high cruising speeds, its endurance, in hours, was poor. The F-105 simply could not respond to a call for immediate support from ground troops, nor was it intended to. Nevertheless, the Thunderchief would eventually win great respect during Vietnam, dropping iron bombs it was never supposed to carry, in a war it was not designed to fight.'

By 1960, TAC's less sophisticated fighter-bomber types (F-84, F-100, etc.) were getting old. Instead of

planning a direct replacement, TAC was working on an even larger and more sophisticated aircraft than the F-105. Nobody appreciated the implications of this trend more clearly than the U.S. Army, which in 1961 began to seriously consider acquiring its own CAS aircraft. The Northrop N-156F (which had not yet received its first Air Force order as the F-5), Douglas A-4 Skyhawk, and Fiat G.91 were evaluated, along with an unusual British aircraft called the Hawker Kestrel, which later became the AV-8 Harrier. Officially they were being considered as potential reconnaissance aircraft, but the ruse fooled nobody, least of all the Air Force. A major battle was fought in the halls of the Pentagon and on the floor of Congress. The Air Force demanded that the Army not be allowed to operate fixed-wing aircraft; the Army demanded that it receive proper support of troops on the ground.

*The Republic F-105 Thunderchief represented all that was wrong with Air Force support from the Army's perspective – too fast to identify small targets, and too thirsty to loiter in a combat zone to support troops on the ground. Nevertheless, the F-105 provided valuable support during the conflict in Southeast Asia. This F-105D-5-RE (58-1173) is seen with sixteen M117 750-pound bombs. Only four bombs (instead of six) could be carried on the inboard wing pylons because of interference with the main landing gear. (San Diego Aerospace Museum Collection)*



Finally, the Army had to accept tight restrictions on the types of fixed-wing aircraft it could operate, but the Air Force was ordered by Secretary of Defense Robert S. McNamara to rebuild its ability to provide battlefield air support. In 1965 the two services agreed that the Army could operate armed helicopters, but in exchange the Army would have to transfer all of its fixed-wing Caribou transports to the Air Force.<sup>2</sup>

Not wanting to divert any serious resources from its newfound nuclear strike role, the revival of close air support within the Air Force was a very limited effort directed at defeating guerrilla forces in an unsophisticated air environment. Air superiority was assumed, and the resulting "counter-insurgency" (COIN) philosophy called for delivering small weapon loads against guerrillas located near friendly forces. In the late 1950s North American Aviation had developed a strengthened, re-engined adaptation of surplus T-28A trainers for the French forces in Algeria, and the Air Force began to procure the similar T-28D for use by indigenous forces and the rapidly growing contingent of U.S. advisors in Vietnam. Various modifications of the venerable North American P-51 Mustang were also evaluated, although the P-51 had never been a favorite for the close support mission where its belly-mounted radiator proved exceptionally vulnerable to ground fire. The first practical application of the new counter-insurgency concept came in South Vietnam, where the Air Force's first COIN detachments arrived in late 1961. They did not fare particularly well.

Without altering the underlying COIN philosophy, the Air Force draft-

ed a requirement for a replacement aircraft of about the same power, payload, and speed of the T-28D. The aircraft was to be armed with fixed 20-mm cannon, and be able to carry a variety of unguided rockets and light bombs. Interestingly, the ability to carry paratroopers was included in the specification. The proposed Light Armed Reconnaissance Aircraft (LARA) was to be built in large numbers for the Air Force, Navy, and Marine Corps, as well as for U.S. allies. North American Rockwell eventually won the LARA competition with the OV-10 Bronco.

The Viet Cong, however, refused to cooperate and began to demonstrate a disturbing proficiency with Soviet-supplied light anti-aircraft artillery (AAA). Losses of T-28Ds mounted steadily in 1963-64, and TAC's COIN experts attributed them mainly to the type's modest speed and lack of armor, limitations largely shared by the LARA. Even before the OV-10 made its first flight, TAC had decided that it would be confined to the forward air control (FAC) mission, and by late 1964 there were beginning to be references to a faster, more heavily armed, Super-COIN aircraft.

The need to replace the increasingly vulnerable T-28D was becoming ever more urgent, and the situation became worse in early 1964 when the Vietnam-based Douglas B-26s were grounded by structural problems. Fortunately, a temporary replacement was available in the Navy's Douglas A-1 Skyraider. The A-1 was not fast, but it was reasonably tough, maneuverable at low speeds, and had a long endurance with a heavy weapons load.

The A-1, called the "Spad" by most, proved by far to be the most suc-

cessful CAS improvisation in Vietnam, and one even shot down a MiG-17 which strayed in front of its four 20-mm cannon. It was a decisive participant in many rescue operations, mainly because it could remain on station long after the sophisticated fighter-bombers had turned for home, out of fuel and ammunition. In the CAS mission, the A-1's endurance allowed it to loiter just behind the battle area and quickly respond to calls for support from ground troops. A small turning radius allowed the A-1 to maneuver and turn among hills and low clouds, in conditions where jets were confined to a single relatively high-speed pass at the target.

The Air Force also used other aircraft for the CAS mission during Vietnam, mainly the F-100 and A-37, but none had the A-1's endurance, so they had to be kept on the ground until needed. Often they arrived too late, or found the tactical situation had changed, and their pilots could not locate targets quickly enough to attack on a single pass. Experience showed that a second pass was frequently fatal to the attacking pilot.<sup>3</sup>

The Air Force finally embarked on procuring the Super-COIN aircraft in the mid-1960s. This concept would ultimately lead to the A-X competition which would be won by the Republic A-10 Thunderbolt II. The Air Force described this aircraft as specifically-suited for supporting friendly forces by providing close air support. In particular, the aircraft would be designed in response to U.S. Army requests for rapid and accurate fire power against enemy forces near friendly troops.

But the U.S. Army was not convinced.

## The Birth of an Idea

On 27 March 1963, an outline specification for a dedicated armed helicopter was submitted to Secretary of the Army Cyrus R. Vance; he was not impressed. In a memo to the Army Chief of Staff, Vance said "After most careful review and consideration, I have concluded that the marginal military advantages represented in the attached proposal to initiate a weapons helicopter development program do not warrant the expenditure involved. Accordingly, the proposal as it now stands is disapproved. ... At the same time I want to emphasize that this disapproval is, in essence, a signal to lift the Army's sights in its efforts to provide aircraft for the helicopter escort role. We must now press forward with speed and imagination to develop a more advanced weapons system which will more nearly approximate the optimum. In view of the foregoing, please have the Staff prepare recommendations aimed at reaching this objective."

The sights were lifted. On 1 August 1964, the Army released a Request for Proposal (RFP) for the

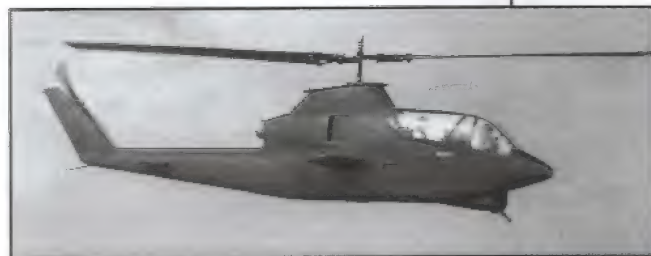
Advanced Aerial Fire Support System (AAFSS). The nonspecific program title masked the fact that AAFSS was to be an all-weather close air support aircraft. The accompanying specification called for a helicopter with a top speed of 220 knots, the ability to hover at 6,000 feet on a 95°F day, and a ferry range of 2,415 miles – enough to fly from California to Hawaii. Keep in mind that the UH-1 had a top speed of 120 knots and the Chinook was limited to 170 knots.<sup>4</sup>

The high speed would allow the AAFSS to escort the new CH-47 Chinooks until they were near the landing zone, then streak ahead and soften up the area with heavy firepower. The AAFSS would then remain in the immediate area, providing close air support while the troops secured their position. Projected armament included a 40-mm grenade launcher, a 30-mm cannon, plus six BGM-71 TOW or Shillelagh<sup>5</sup> missiles. The new aircraft would include an advanced all-weather fire control system that could also operate at night. Up until this time, a fire control system had never been fitted to a helicopter.<sup>6</sup>

The RFP went out to 148 interested<sup>7</sup> organizations, and carried a 23 November 1964 deadline for the submission of concept definition proposals. From this data, one or more designs would be selected for further study and development. Final proposals for a production machine would follow on 1 September 1965, and a contract award was expected on 1 November 1965.<sup>8</sup>

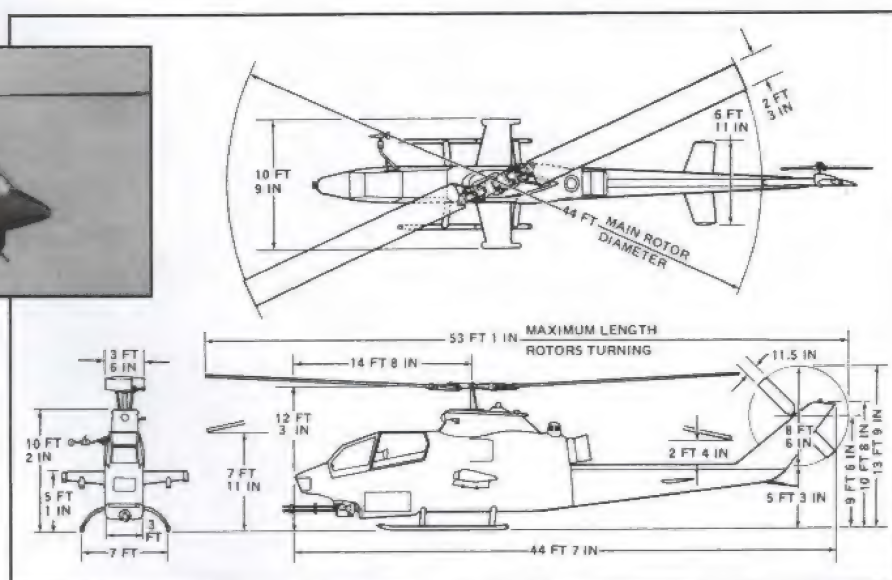
## Reality Rears its Ugly Head

The AAFSS would provide the Army with an extremely advanced weapons system – at some point in the future. In the meantime, there was still the short-term problem in Southeast Asia. The Army began an evaluation of existing helicopters that might fill the gap until the AAFSS could be developed and fielded. During late 1965, Colonel H. L. Bush chaired a committee to look at the various alternatives. These included variants of the Boeing-Vertol CH-47 Chinook, Navy-Kaman UH-2A Seasprite, Navy-Sikorsky SH-3 Sea King, and perhaps the most radical of all, the Bell Model 209. Any aircraft would need to be as fast as the troop-carrying Chi-



*The privately-funded Bell Model 209 (above) was the prototype for the HueyCobra gunship. (Bell Helicopters)*

*Right: A three-view of the developed AH-1S Cobra variant. (U.S. Army)*



nooks, carry a wide variety of weapons, and be available within 24 months.

The only new aircraft on the list was the Model 209. In 1963, Bell had extensively modified a Model 47G-3B into the OH-13X Sioux Scout. Power came from a single Lycoming VO435 265 hp piston engine driving the characteristic Bell two-blade rotor. The aircraft had a two-person tandem cockpit in a streamline fuselage and an Emerson Electric TAT-101 chin turret with a pair of M60C 0.30-caliber machine guns. In itself, the Sioux Scout was not a contender – it suffered from the same problem as all piston-powered helicopters; it was slow.

But the Sioux Scout was never intended to enter production. It was, instead, a proof-of-concept vehicle. It was a cheap and fast way to take the mechanical parts of an existing helicopter and build a dedicated fighting aircraft. It worked, and it provided Bell with the confidence to go ahead with the Model 209.

During the summer of 1965, Bell began developing the Model 209 HueyCobra as a company-financed venture, predating the Bush committee by a few months. Essentially, the new Model 209 was the powerplant, transmission, rotor, and tail boom from the UH-1C grafted onto a new streamline forward fuselage.

The fuselage housed a pilot and gunner in tandem, along with a turret with a 7.62-mm minigun. In addition to being aerodynamically cleaner, the new fuselage presented a smaller frontal area for the enemy to shoot at. A pair of stubwings provided four locations to carry weapons such as 2.75-inch rocket pods and TOW missiles.

On 7 September 1965, the first Model 209 (civil N209J) made its maiden flight. It looked much like the Cobras that still serve with many nations around the world. The most notable difference was the retractable skid-type landing gear – something that would be deleted from the production machines.

On 11 March 1966, the Bush committee concluded that the Model 209 was most suited to the armed escort role, and recommended that the Army procure a limited number to serve in Southeast Asia until the AAFSS could be developed. Therefore, on 4 April the Army ordered two preproduction AH-1Gs, followed nine days later by a production order for 112 Cobras procured with FY66 funds. Over 1,000 AH-1s would be built in the next 5 years.<sup>9</sup>

### The Competition, Round I

At the same time, twelve aerospace companies expressed interest in participating in the concept definition phase of the AAFSS competition. Two of these quickly emerged as front-runners – with remarkably similar designs. That Sikorsky Air-

*The Bell AH-1 Cobra is still serving various armed forces around the world, including small numbers in the U.S. Army. Pictured is the ultimate development of the single-engine AH-1F. (Bell Helicopters)*



craft, a long-standing helicopter manufacturer, was one of these came as no surprise to anybody. After all, Sikorsky had largely invented the modern helicopter. What was a surprise was that the second design came from the Lockheed-California<sup>10</sup> Company, which had little if any practical helicopter experience. The only other real contender was the Bell Iroquois Warrior, essentially a revised version of the Model 209 Cobra, being slightly larger and more powerful.

All of the competitors submitted their proposals on 23 November 1964, as scheduled. The U.S. Army Aviation Materiel Laboratories (AVLABS) at Fort Eustis, Virginia, spent the next three months evaluating the data, and on 9 March 1965 Sikorsky and Lockheed were selected to continue development of their concepts. The two companies would have until August 1965 to further refine their technical and cost proposals before a final winner was selected.

## Sikorsky S-66

The Sikorsky entry in the AAFSS competition was the S-66, a "semi-compound" helicopter loosely based on the mechanicals from the SH-3 Sea King. The main propulsive power came from the main rotor, like a conventional helicopter, but small wings unloaded the rotor at high speeds. Primary control of the aircraft was always accomplished by manipulating the main rotor, and no aerodynamic control surfaces were installed on the wings. A unique tail rotor acted as a conventional anti-torque rotor below 60 knots, and rotated 90° to point aft at high speeds (above 100 knots), providing a small additional measure of thrust. Sikorsky called this a Rotoprop, and it was positioned automatically as a function of speed, although the pilot could override it manually if necessary. The large four-bladed main rotor was a conventional articulated system.<sup>11</sup>

Studies conducted by Sikorsky

showed that speeds above 200 knots would not materially improve a helicopter's chances of successfully completing its mission. Because of this, the S-66 was designed to operate at 200 knots, with a short dash capability to approximately 250 knots. Instead of speed, Sikorsky concentrated on providing increased agility in the 0-100 knot regime. The designers felt that an articulated rotor system was best for providing this agility. Power came from a single 3,400 shp Lycoming T55 turboshaft engine situated slightly aft of the main rotor mast to improve the center of gravity. Directional stability at high-speed was provided by a T-tail located above the Rotoprop.

A nose-mounted turret contained the main armament, and the wings provided hard-points for additional weapons. A variety of target acquisition devices, including low-light television and infrared were proposed. The entire weapons system was designed to be modular so

*The Iroquois Warrior was a slightly larger and more refined version of the Model 209 (AH-1G) that was submitted in the first round of the AAFSS competition.*

*The tailboom is obviously borrowed from a UH-1. But the Army felt that the Lockheed and Sikorsky designs had more potential, and the Iroquois Warrior never progressed past the mockup shown here. (Bell Helicopters)*



**CONFIDENTIAL**

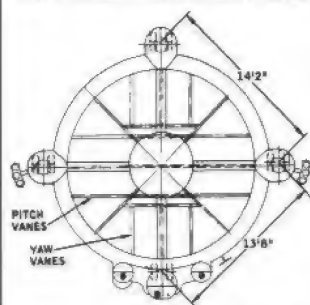
This data furnished in response to RFP No. NEG-3, shall not be disclosed outside the Government or be duplicated, used or disclosed in whole or in part for any purpose other than to evaluate the proposal; provided that if a contract is awarded to this offeror as a result of or in connection with the submission of such data, the

Government shall have the right to duplicate, use, or disclose this data to the extent provided in the contract. This restriction does not limit the Government's right to use information contained in such data if it is obtained from another source.

## Convair Model 49

### DATA

ENGINES: THREE LYCOMING LTC4B-11  
 ROTORS: TWO THREE BLADED CONTRA ROTATING  
 TOTAL ACTIVITY FACTOR = 800,  $C_{L1} = 0.5$   
 TIRES: 7,00-6 TYPE III



A-A  
 PROJECTED AREA  
 ASPECT RATIO  
 TAPER RATIO  
 CHORD  
 AIR FOIL SECTION  
 INSIDE DIAMETER  
 THICKNESS  
 INCIDENCE RANGE

SHROUD	PITCH VANES	YAW VANES	CONTROL BODY STRUTS
205 SQ. FT.	112.5 SQ. FT.	64 SQ. FT.	-
1.25	1	1	-
12.8 FT.	2.5 FT.	2.5 FT.	4.75 FT.
MODIFIED RAF 6	0010	0010	-
16 FT.	-	-	-
10% c	10% c	10% c	16.6% c
-	$\pm 30^\circ$	$\pm 30^\circ$	-

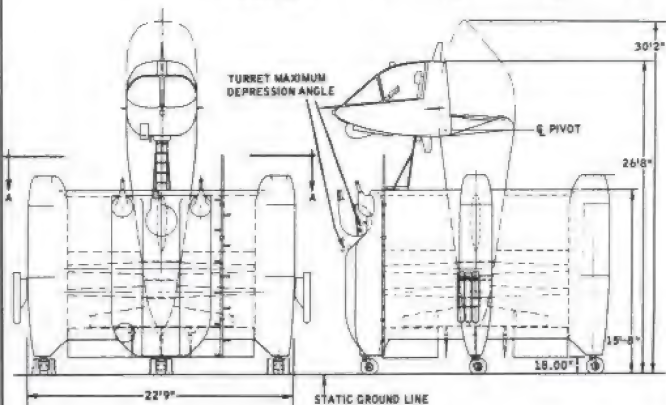


Figure 4-10. Three-View of Initial Point Design Configuration

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**CONFIDENTIAL**



The most unique proposal in the AAFSS competition came from the San Diego division of Convair. The Model 49 did not fit the normal mold for either an airplane or a helicopter, and represented something entirely new. Propulsive power came from turbine engines driving counterrotating propellers within the shroud. Convair believed that the system was inherently more reliable than a conventional helicopter, and pointed out the only pilot control inputs involved directional control and setting rotor blade angle and engine speed. The crew of two occupied an articulating capsule on top of the shroud and was provided with a full array of sensors. The engines, fuel, crew capsule, and avionics bays were equipped with dual-property steel armor for protection against 12.7-mm projectiles.

A wide variety of weapons were proposed for use on the vehicle. The normal complement included two side turrets with either XM-134 7.62-mm machine guns or XM-75 40-mm grenade launchers. Each turret was provided with either 12,000 rounds of 7.62-mm ammunition or 500 40-mm grenades. A center turret carried an XM-140 30-mm cannon with 1,000 rounds of ammunition. The center turret could also mount 500 WASP rockets, or a second 30-mm cannon. Each of the turrets could rotate and elevate and was capable of being fired while sitting on the ground, in a hover, or during high-speed forward flight. Mechanical stops were provided that prevented any of the weapons from firing at the nose of the crew compartment when it was articulated forward/down. Four hard-points were located on two of the engine nacelles; each could carry a fuel tank, three BGM-71 TOW missiles, or three Shillelagh missiles. Alternately, one of these hardpoints on each nacelle could carry a single M40A1C 106-mm recoilless rifle and 18 rounds of ammunition. The 106-mm cannon had an effective range of 10,000 yards, and was effective against hardened targets. All of the hard points could rotate so that they could be oriented into the wind during high-speed flight, or aimed while being fired from either forward flight or a hover. Four external fuel tanks provided up to 1,200 gallons additional fuel for ferry flights. (Convair via the San Diego Aerospace Museum Collection)



WEAPONS UP

DASH TO TARGET



HOVER FIRING MODE



WEAPONS DOWN

DASH FIRE MODE



TRANSITION TO FLIGHT

## Convair Model 49 AAFSS



TRANSITION PRE-LAND



LADDER DOWN

STAND-BY PARKED



MAINTENANCE



LADDER UP

LANDING

The mission modes for the Model 49 are shown above. The shrouded-rotor vehicle was capable of vertical takeoff and landing, just like a helicopter, and was also capable of hovering. The propulsion system consisted of three shroud-mounted Lycoming LTC4B-11 turboshaft engines, although the General Electric T64, Allison T56, and Pratt & Whitney JFTD12 were also investigated. The engines were coupled through clutches, shafting, and gear-reduction units to contra-rotating variable pitch rotors within the shroud. The thrust and lift systems were extremely interrelated, and the shroud amplified the thrust under some conditions, compensating for the relatively small diameter of the rotors. The engines and gear boxes were located in three of the nacelles along the sides of the shroud; the fourth nacelle contained the weapons and avionics. The overall control system was thought to be similar to conventional helicopters except for the removal of the cyclic pitch feature. Convair planned to leverage the experience gained during the Navy XFY-1 Pogo program in the areas of vertical control systems and powerplant installations, and believed the development risk was minimal. (Convair via the San Diego Aerospace Museum Collection)



*Sikorsky tested its Rotoprop concept on this modified S-61 (N318Y). The Rotoprop brought some of the capabilities found in Lockheed's pusher propeller, but was not as flexible in operation. (Sikorsky via David Lednicer)*



*An early version of the S-66 is shown in the middle of the page, while the final version is above. Note the T-tail on the final version, sitting above the translating Rotoprop. The cockpit area of the final version bore an uncanny resemblance to the later Soviet Hind gunship. (Tony Landis Collection)*

that it could be reconfigured easily between missions. An integrated avionics system provided an all-weather capability<sup>12</sup>

A number of innovations were proposed by Sikorsky to reduce maintenance and increase reliability. All components were designed to be replaced on the basis of condition rather than time using an extensive on-board systems monitoring capability. The entire rotor head was designed without grease fittings, using Teflon bearings and self-lubricating bearings instead.

The S-66 had a two-man crew in separate tandem cockpits with about 5 feet between them, a design intended to lesson vulnerability to hostile fire. The resulting configuration bore an uncanny resemblance to the much-later Soviet Hind gunship. The crew compartment, as well as some other areas of the fuselage, were protected by armor plate. The main landing gear retracted forward into small sponsons at the leading edge of the wing.

## Lockheed CL-840

The Lockheed design was nothing if not innovative. Perhaps the single most unusual feature was the rigid rotor system which eliminated the normal flapping and lead-lag hinges, but still incorporated feathering bearings. A more correct nomenclature was "hingeless rotor," but rigid rotor was the choice made by the popular press, and it stuck.<sup>13</sup> Rigid rotors had been proposed for use on helicopters for years, but none had proved practical – as demonstrated by Cierva's first autogyro. The concept promised speed and stability coupled with instant maneuverability, uncomplicated construction, and light weight. But historically they had been extremely unstable and prone to catastrophic failure. Lockheed believed they had overcome this.<sup>14</sup>

The rest of the helicopter was equally as unusual. A long streamline fuselage contained a crew of two in tandem under a single canopy. The vertical stabilizer pointed downward instead of upward, and housed the swiveling tail wheel. A conventional anti-torque rotor was located on the left side, and a dedicated pusher-propeller was located on the extreme rear of the tail boom. Large sponsons along the side of the fuselage housed the (mostly) retractable main landing gear, as well as fuel and an auxiliary power unit (APU). The sponsons served as work plat-

forms to allow ground crews to service the engine and main rotor, and also served as walkways to the cockpits. Originally, the sponsons had been separate from the fuselage, located about 12 inches onto the wings, but structural and packaging considerations moved them directly next to the fuselage.

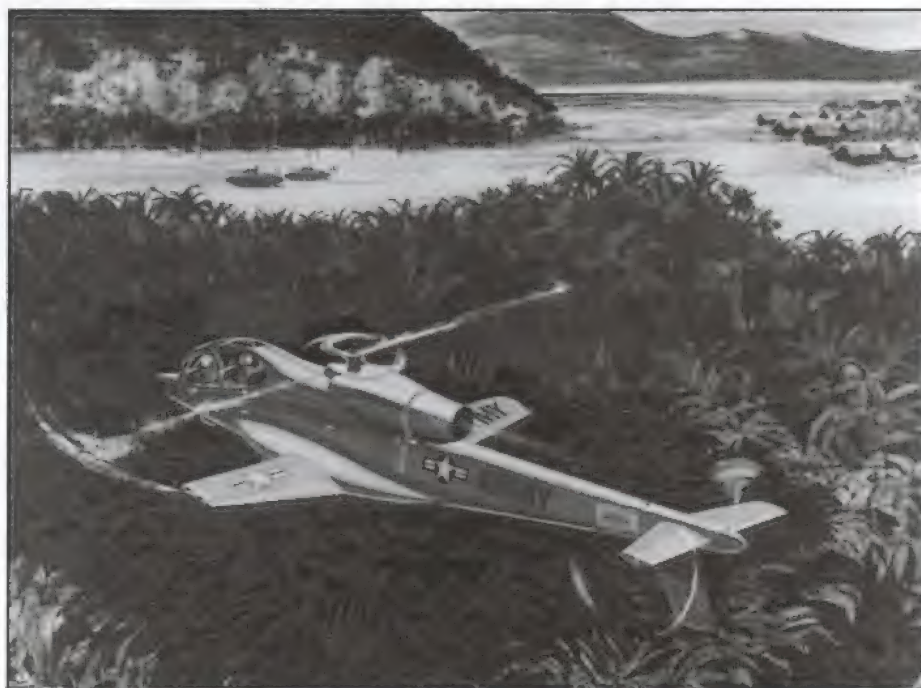
Power was provided by a single 3,425 shp General Electric (GE) T64-GE-16 turboshaft engine. Lockheed's performance predictions were fantastic: acceleration from 0 to 200 knots in level flight was estimated at 38 seconds – 200 knots to full stop took just 17 seconds. Lockheed estimated the top speed at 220 knots at sea level and a service ceiling of 26,000 feet. The maximum rate of climb would be 3,420 feet per minute. Normal operational range would be 872 miles, and ferry range using external fuel tanks would be 2,870 miles.

Although Lockheed had never built a production helicopter, it had flown several prototypes to test its hingeless rotor concept. The idea

had begun in the late 1950s, with engineer Irven Culver leading the way. Culver believed that conventional helicopters were too unstable, resulting in them being difficult to fly. Most pilots of the era would agree. Culver also believed that an inherent feature of all rotating systems – gyroscopic inertia – could be used to solve this problem. The obvious way to do this was to attach the rotor blades directly to the rotor hub. This let the gyroscopic effect of the hub balance the system, and also eliminated the flapping and lead-lag hinges that required a great deal of maintenance on conventional helicopters. In July 1966, Culver and Lockheed would be granted U.S. patent US3261407 for the hingeless rotor concept.

It was decided that the concept was promising enough to be tested. But instead of heading for the wind tunnel (computer simulations were years in the future), Lockheed decided to build a small radio-controlled model, following somewhat in the footsteps of Cierva 30 years

*The original artist concept for the CL-840 was remarkably close to the final Cheyenne design. Several variations of this art exist, some with the tanks in the background, some showing the aircraft attacking the village at the upper right. (Lockheed)*



earlier. The fact that no RC model helicopter had ever been flown did not seem to deter Lockheed. The model emerged with a 5-foot diameter, two-bladed main rotor with a fixed collective pitch and direct cyclic pitch control. Power came from a single McCoy 60 model airplane engine which turned the rotor through a combination belt-and-gear drive with an 8-to-1 reduction ratio. The radio control was a simple on-off system for pitch, roll, and throttle.<sup>15</sup>

The configuration proved very unstable. The team agreed that using direct cyclic pitch control would not work, and set about designing a gyro stabilization system. One of the first lessons learned from this exercise was that the main blades would have to be swept slightly forward to prevent the gyro from diverging; the forward sweep provided flapping-moment feedback to the gyro. With

the gyro and forward-swept blades, the model helicopter proved very stable and easy to fly. The concept had been proven, and now it was time for a full-scale aircraft.

In July 1959 the original small part-time team was expanded to five full-time engineers and given a walled-off corner of the experimental flight test hangar in Burbank. Their assignment was to build a small two-seat helicopter carrying the Lockheed designation CL-475.<sup>16</sup> The two-bladed main rotor was essentially a scaled-up version of what had been tested on the RC model using wood blades with a fixed 7° collective pitch. Thrust modulation was accomplished by changing the rotor speed.

The fuselage was fabricated from steel and aluminum tubing covered with fabric, except for the cockpit area that was molded from fiberglass. Power came from a single

180-hp Lycoming piston engine driving through a Bell Model 47 transmission. The two-bladed tail rotor had wooden blades, twisted straps for feathering, and a small gyro to assist with yaw damping.

When the CL-475 (civil registry N6940C) was completed, it was trucked to a remote corner of Rosamond Dry Lake, near Edwards AFB. The aircraft first flew on 2 November 1959, just five months after the project began. After landing, the pilot, who was used to flying conventional helicopters, reported that the flight was "kind of rough." To find out how rough, Culver took a short ride. After landing, he was visibly shaken and decreed: "Keep that thing on the ground until we solve that vibration."<sup>17</sup>

Three- and four-bladed wooden rotors were quickly built and tested with much better results, and ultimately, the three-bladed configura-



*The CL-475 with the original two-bladed rotor system parked on Rosamond Dry Lake, north of Los Angeles. Note the streamlined rotor hub and the two-armed counterweight. (Lockheed)*

*The CL-475 with the second-generation aluminum three-blade main rotor, shown on 1 February 1961. Note the large ring-shaped gyro under the rotor. The person holding the front wheel is Dick Cotton. (Lockheed)*

tion was settled upon. Testing lasted for six months and showed the little helicopter was very stable and easy to fly. To illustrate the point; engine problems during one flight caused the aircraft to land several miles from the camp. By the time the engine was fixed, the pilot had gone home. Not wanting to tow the helicopter across the lakebed, one of the mechanics (who had a fixed-wing license) hopped in and flew it back to the camp without difficulty, despite the fact that he had never been in a helicopter before.

As the project progressed, it was consolidated into the mainstream engineering organization in Burbank. By mid-1960 the flight test operation was also moved closer to Burbank, to a field near the Lockheed Rye Canyon research facility. By this time the little helicopter had an aluminum three-bladed rotor, and the gyro was a ring just under the rotor hub, fastened directly to the swashplate. Springs connected the cockpit controls to the swashplate, allowing the pilot to produce cyclic pitch by precessing the gyro. The simple fixed-collective-pitch but variable-RPM thrust control concept had been replaced by the more conventional fixed-RPM but variable-collective-pitch system.

Pilots from the military, FAA, and NASA were all invited to fly the CL-475. The helicopter was somewhat underpowered, but visiting pilots were nonetheless impressed by the stability of the aircraft. One



of the most impressive features was the ability, after establishing a good trim, of flying hands-off for a considerable period of time – something conventional helicopters of the period were unable to accomplish.<sup>18</sup>

Although Lockheed's original intent had been to develop an easy-to-fly

helicopter for the civilian market, the company was not blind to the possibility of military roles. In 1961, Lockheed used this rotor design in its proposal for the Army Light Observation Helicopter (LOH) competition. Although the Army pilots that had flown the CL-475 had been impressed, the Army wanted a sim-



*The engine access door has been removed, showing the 180-hp Lycoming piston engine used in the CL-475. The ring gyro used on the three-bladed rotor is clearly visible in this 30 November 1960 photograph. (Lockheed)*

ple, low-risk design for the LOH so that it could be fielded quickly. Hughes was eventually selected to supply the OH-6 (Model 500) Cayuse, although the LOH competition also gave birth to the Bell OH-58 Kiowa (Model 206 JetRanger), two of the most successful turbine helicopters in history.

Nevertheless, the military was intrigued by the hingeless rotor system and Lockheed was awarded a Navy<sup>19</sup> contract for two XH-51As (BuNo 151262/151263). Known as the CL-595 Aerogyro (or the Model 186, depending whom you talk to) within Lockheed, the XH-51A would be larger and faster than the LOH aircraft. Since high-speed was a major goal, the design department decided to "make it look fast" – and

it certainly succeeded. The streamline fuselage was flush-riveted and a retractable skid-type landing gear was fitted. In a move that greatly improved the aesthetics, and also reduced drag, the rotor control rods were enclosed inside the rotor shaft. A variety of ventral fins would be seen on the aircraft over the course of the flight test program.

The first XH-51A made its maiden flight on 2 November 1962 with Lockheed test pilot Donald R. Segner at the controls. The aircraft was powered by a 550-shp Pratt & Whitney PT6B-9 turboshaft engine. The initial three-blade rotor was soon replaced by a four-bladed unit to solve an irritating resonance (vibration) with the fuselage. Much of the XH-51A's early demonstrations cen-

tered around proving critics wrong. There were many, both within the industry and the popular press, that thought a "rigid-rotor" was inherently limited in capability. Basic maneuverability demonstrations quieted many; others required more proof. Some claimed that the gyro-stabilized rotor would be susceptible to wave motions, and that the XH-51A could not operate off ships. To counter this, a tilting platform was constructed at Burbank and the XH-51 conducted non-flying tests while attached to it. Next came demonstrations aboard the USS *Ozborn* (DD-846) while cruising off the California coast; the XH-51A passed with flying colors. Critics claimed that the recoil from a gun would upset the gyro; tests were conducted with a 0.30-caliber machine gun attached to one side. Accuracy, using a simple fixed sight, was excellent and no stability problems were encountered. The XH-51A later went on to demonstrate that it could perform anti-submarine duties using dipping sonar while in a stable hover.

The XH-51A demonstrated a top speed in level flight of 151 knots with the three-bladed rotor, and 175 knots with the four-blade unit. Don Segner remembers seeing more than 200 knots<sup>20</sup> in a slight dive. The aircraft participated in a 125-hour joint Army-Navy evaluation at NATC Patuxent River, Maryland, where pilots were impressed by its excellent handling qualities.

In fact, NASA was so impressed that it ordered a single XH-51N for use at the Langley Research Center. The XH-51N differed in using a three-bladed main rotor, having five seats (like the Model 286), and a gross takeoff weight of 4,000 pounds. No record of its fate could be found.



*The diminutive size of the CL-475 is illustrated in this 17 September 1960 portrait with other aircraft at Burbank. From the front: CL-475, Cessna 180, DC-3 with an F-104 radome, P2V Neptune, L-188 Electra, P-3B, another Electra testbed, and the "Rotodome" Connie. (Lockheed)*

*The first XH-51A (BuNo 151262) shows the clean lines of the XH-51A, as well as the unusual ARMY-NAVY markings indicating it was a joint-service program. (Lockheed)*

All of this confirmed to Lockheed that it had a viable commercial product, leading to the construction of two Model 286<sup>21</sup> (N286L and N286LC) five-seat commercial demonstrators. The design was certificated<sup>22</sup> by the FAA in 1966 and Lockheed took the helicopters on the air show circuit to demonstrate their capabilities. During these air shows the aircraft demonstrated the ability<sup>23</sup> to perform loops, rolls, split-S maneuvers, and proved that they retained positive control even during (short) inverted flight. The helicopter proved exceptionally stable, and could easily have been IFR-qualified, although Lockheed decided not to at the time. Some within Lockheed, however, worried about Lockheed's lack of dealer and support organizations for non-airline and non-military customers.

One of the primary backers of the helicopter initiative had been Lockheed Chairman Robert Gross. When he passed away in 1966 the board of directors began to take a more cautious approach, and decided not to offer the Model 286 to civilian customers. The aircraft were then marketed as antisubmarine warfare models, and the Royal Netherlands Navy ordered a dozen of them.

But Lockheed was in turmoil at the time, and the order was never consummated. The two 286s were used as executive transports for several years before being sold in non-flying status to a Southern California collector. They were both destroyed in a hangar fire in 1988.



*Artist concept of a Navy H-51 antisubmarine warfare variant. Note the large torpedo suspended under the fuselage and the dipping sonar. One of the XH-51As was used to test the design's ability to operate off of a small naval ship and to use dipping sonar. (Don Segner Collection)*

The first XH-51A (BuNo 151262) was strapped to a tilting platform at Burbank to evaluate its ability to operate on the pitching deck of a ship at sea. These tests centered on the possibility of tail boom strikes as the ship pitched violently in heavy seas. The aircraft passed the evaluations with no major concerns. (Lockheed)



After being evaluated on the tilting platform, the first XH-51A was flown off the California coast and operated from the destroyer USS Ozbourne (DD-846). The evaluations proved that the XH-51A was extremely stable in all flight regimes, including using a simulated dipping sonar. In fact, the Lockheed design proved a great deal more stable than most contemporary Navy helicopters. (San Diego Aerospace Museum Collection)



The three XH-51s hover in formation in front of the Lockheed plant. At left is the Compound (BuNo 151263), with the other XH-51A (BuNo 151262) at left. The single XH-51N (NASA 30) is in the center. (Lockheed)

Sammy Mason, at the controls of the first Model 286 (N286L), demonstrates its ability to go inverted over the top. All of the Lockheed hingeless rotor helicopters could perform maneuvers such as this, but Don Segner recalls that the pilots only did them in the two Lockheed-owned aircraft. Even today it is unusual for a helicopter to go inverted at the top of a loop since it imposes substantial stresses on the rotor system, and most helicopter engines and transmissions are not equipped to be lubricated while inverted. (Lockheed)

The Lockheed Model 286 was substantially similar to the XH-51 design. The brochures called it a five-seater, but in reality the rear seat was more comfortable for only two occupants, making it a more practical four-seater. Like the XH-51A, it had retractable skid-type landing gear, further enhancing its streamlined appearance. (Lockheed)





*NASA was so impressed by the capabilities of the XH-51As that it ordered a single XH-51N for the Langley Research Center in Virginia. (Lockheed)*



*Proving the stability of the XH-51A – a large weight (the man – Bill Foulke) far offset from the center of gravity, and the pilot with his hands off the controls and waving to the photographer. (Lockheed)*

### Compounding

The next logical step in the development of a high-speed helicopter involved using jet engines and wings to unload the main rotor during forward flight. Unloading

the rotor eliminates the retreating-blade stall which is the most serious limitation to high speed flight in a helicopter. In its purest sense, the rotor would be free to windmill in the airstream, and control of the aircraft would pass to conventional

aerodynamic control surfaces on the wings. This type of aircraft is known as a compound helicopter.

In 1963 the Army awarded contracts to four helicopter manufacturers to convert aircraft to the compound configuration. Bell used a UH-1, Kaman a UH-2, Sikorsky an S-61, and Lockheed used one of the XH-51As (BuNo 151263). Here the hingeless rotor on the Lockheed design had a huge advantage. Even with the rotor fully unloaded, it still was able to provide the same high level of pitch and roll control, eliminating the need for conventional aerodynamic control surfaces on the wings. This simplified the control system tremendously.

The XH-51A Compound<sup>24</sup> used a 2,600-lbf Pratt & Whitney J60-P-2 turbojet engine enclosed in a nacelle salvaged from a wrecked Saberliner mounted on the left side of the fuselage. A pod on the extreme tip of the right wing contained a battery and flight test equipment to counteract the weight of the jet on the left. The right seat was retained for the pilot, and the left side of the cockpit was dedicated to flight test instrumentation. In anticipation of higher speeds, Lockheed reinforced the clear plexiglass canopy of the compound, but experience would show that it needed further reinforcement. Other changes included a 30 percent larger vertical stabilizer, created by adding 2.5 inches to the chord on the upper 75 percent of the stabilizer. The horizontal stabilizer was made larger – 24.2 instead of 19.8 square feet – by adding 12 inches to each side and extending the chord. During the flight test program, a vibration was cured by adding weights on the tip of each horizontal stabi-

lizer, and also using an external brace on the underside that attached to the fuselage.<sup>25</sup>

The jet engine gave the Compound a source of thrust independent of the main rotor system, but could exhaust its fuel supply in only 20 minutes. In forward flight the extra thrust, combined with the lift produced by the small wings, unloaded the main rotor, reducing the tip speed and blade angle, finally eliminating retreating-blade stall tendencies, and significantly reducing the drag created by the rotor system.

This allowed the XH-51A Compound to fly faster – much faster.



*The XH-51A Compound used a set of small wings and a single J60 turbojet engine to achieve a substantial speed increase over the basic design. A close examination will show the "NAVY" markings have been deleted since the Compound was an Army-funded project. (Lockheed)*



*Army Cheyenne project manager Emil "Jack" Kluever poses with the XH-51A Compound on 3 February 1968. The name Little Chief has been painted to the side of the J60 nacelle. Note the additional bracing low on the forward windscreens – something found necessary after the windscreen began bowing inwards at high speeds. (Lockheed)*



The CL-475 is currently in storage at the Army Aviation Museum at Fort Rucker, Alabama, as this May 1999 photo shows. (Tony Landis)



The first XH-51A was also in storage at Fort Rucker in May 1999. Note the "Royal Aircraft Establishment" marking above "ARMY." (Tony Landis)

The first flight of the Compound was on 10 April 1965, with Don Segner again at the controls. A 78-flight high-speed flight envelope extension contract research program began in May 1965, and the Compound eventually recorded a maximum speed of 263 knots in level flight.<sup>26</sup> It could accelerate from hover to 200 knots in 45 seconds, turn 360° in a hover in only 5 seconds, sustain bank angles of 120°, and had a usable roll rate of 50° per second. Even at a forward speed of 200 knots, the XH-51A could sustain +3-g turns, and a rate of climb of over 3,500 feet per minute was demonstrated. Segner routinely flew the Compound between the Burbank factory and the Oxnard test location in only 18 minutes. Lockheed had successfully proven that the hingeless rotor concept could work.

The CL-475 and both XH-51As are currently at the U.S. Army Aviation Museum at Fort Rucker, Alabama.

<sup>1</sup> Jenkins, Dennis R., *Fairchild-Republic A/OA-10A Warthog*, WarbirdTech Series Vol. 20, Specialty Press, 1998, pp. 6-10. <sup>2</sup> Foreman, Brenda Dr., *What Killed the Cheyenne*, *VertiFlight*, Vol. 42 No. 3, May/June 1996, p. 23. <sup>3</sup> Jenkins, Dennis R., *Fairchild-Republic A/OA-10A Warthog*, WarbirdTech Series Vol. 20, Specialty Press, 1998, pp. 6-10. <sup>4</sup> Prouty, Ray W. and Yackle, Al R., *The Lockheed AH-56 Cheyenne – Lessons Learned*, AIAA Document 92-4278, presented at the AIAA Aircraft Design Systems Meeting, 24-26 August 1992, Hilton Head, S.C., p. 5. <sup>5</sup> The Shillelagh was never adapted for aircraft use; its primary user was the M551 Sheridan light tank. <sup>6</sup> Hewson, Robert, *Beyond the Frontiers: Lockheed AH-56 Cheyenne – The Lost Tribe*, *Wings of Fame*, Vol. 14, AIRtime Publishing Inc., 1999, p. 138. <sup>7</sup> Many companies and individuals receive RFPs other than potential prime contractors. In this case, the majority of the organizations were possible subcontractors and vendors that would contact the expected primes looking for business. <sup>8</sup> Hewson, Robert, *Beyond the Frontiers: Lockheed AH-56 Cheyenne – The Lost Tribe*, *Wings of Fame*, Vol. 14, AIRtime Publishing Inc., 1999, pp. 139-141. <sup>9</sup> Peacock, Lindsay, *AH-1 HueyCobra*, Osprey Combat Aircraft Series No. 9, Osprey Publishing, London, 1987, p. 6. <sup>10</sup> The Lockheed-California Company was a division of the Lockheed Aircraft Company; now the Lockheed Martin Corporation. <sup>11</sup> Brown, David A., *Sikorsky plans 'Semi-Compound' AAFSS*, *Aviation Week and Space Technology*, 10 May 1965, p. 105. <sup>12</sup> Ibid. <sup>13</sup> Prouty, Ray W. and Yackle, Al R., *The Lockheed AH-56 Cheyenne – Lessons Learned*, AIAA Document 92-4278, presented at the AIAA Aircraft Design Systems Meeting, 24-26 August 1992, Hilton Head, S.C., p. 1. <sup>14</sup> Hewson, Robert, *Beyond the Frontiers: Lockheed AH-56 Cheyenne – The Lost Tribe*, *Wings of Fame*, Vol. 14, AIRtime Publishing Inc., 1999, p. 141. <sup>15</sup> Prouty, Ray W. and Yackle, Al R., *The Lockheed AH-56 Cheyenne – Lessons Learned*, AIAA Document 92-4278, presented at the AIAA Aircraft Design Systems Meeting, 24-26 August 1992, Hilton Head, S.C., p. 2. <sup>16</sup> This represented the 475th design of the Lockheed-California Company; why CL instead of LC has never been clear. <sup>17</sup> Prouty, Ray W. and Yackle, Al R., *The Lockheed AH-56 Cheyenne – Lessons Learned*, AIAA Document 92-4278, presented at the AIAA Aircraft Design Systems Meeting, 24-26 August 1992, Hilton Head, S.C., p. 2. <sup>18</sup> Ibid. p. 3. <sup>19</sup> The project was a joint Army-Navy undertaking, but the Navy handled all contractual matters. <sup>20</sup> The first flight above 180 knots showed an interesting limitation of the cockpit instrumentation. The airspeed indicator, although marked to 220 knots, had a limit peg at 180 knots – the needle physically could not go any higher. The peg was quickly removed. <sup>21</sup> The Lockheed CL designations are used for design studies and prototypes. Once a design has been sold, or expected to be sold, a Model number is assigned. <sup>22</sup> FAA Type Certificate Number H5WE, dated 30 June 1966. <sup>23</sup> It should be noted that any helicopter can perform a roll or loop, but it must maintain positive-g to keep the rotor loaded and maintain control. The advantage of the rigid-rotor is that it can go to zero or negative-g. <sup>24</sup> Although "compound" describes the configuration, Lockheed also used the term as the aircraft's name, at least unofficially. <sup>25</sup> Lockheed video documentary, *Testing the XH-51 Compound*, 1966. <sup>26</sup> The Bell UH-1 compound, which used two jet engines and had an even more limited range, eventually achieved 274 knots.

# ... AND THE WINNER IS

## THE AAFSS ENTERS DEVELOPMENT

**S**ikorsky and Lockheed submitted their final technical proposals on 11 August 1965, with the cost proposals following on 1 September. A careful review of the proposals led to Lockheed being announced the winner on 3 November. The deciding factor in Lockheed's favor had been the stability promised by the hingeless rotor; the Army felt it would make a better weapons platform. The Army wanted an initial production run of 200 aircraft at an estimated unit cost of \$500,000.

What happened then, although not fully appreciated at the time, would ultimately doom the Cheyenne. The AAFSS was the first major Army weapons system to be developed

under new rules laid out by Secretary of Defense Robert S. McNamara. This process involved a three-phased approach: program definition (Phase 1); engineering development (Phase 2); and production (Phase 3). The Total Package Procurement (TPP) resulted in the winning company being issued a contract that covered the program from the cradle to the grave, instead of the more normal method of issuing a development contract, then deciding whether to produce the aircraft after it has successfully passed its testing. McNamara felt the TPP put pressure on the contractor to perform better since the contractor had to agree to the total program cost up front, and could not ask for additional funds to fix

subsequent problems. The military felt it forced them to buy an aircraft that might or might not live up to its promise since they had to agree to production before the aircraft was even designed. The contractors felt it was an unfair burden to have to agree to a fixed-price development cost on a project that was state-of-the-art and subject to many requirement revisions. In short, nobody liked the arrangement except McNamara. The unfortunate Army program manager that inherited all of this was Lt. Colonel Emil E. "Jack" Kluever.<sup>1</sup>

The \$12,750,000 contract<sup>2</sup> for ten prototype CL-840s (manufacturer serial numbers 1001-1010) was signed on 23 March 1966. At the



*The major external difference between the AH-56A mockup presented on 7 June 1966 and the actual aircraft was the design of the 30-mm belly turret. Production aircraft would use a more faired installation. (Lockheed)*

same time, the helicopter was designated AH-56A-LO<sup>3</sup> and ten military serial numbers (66-8826/8835) were assigned. The ten aircraft would include a single non-flyable ground test vehicle (GTV), one flyable prototype without a weapons system, and eight pre-production aircraft. A separate static test airframe (msn 1000) would be tested in a laboratory at Rye Canyon, mounted upside down in a rig with multiple hydraulic jacks that could simulate most any airborne stress likely to be encountered by the air-

craft. This airframe would eventually be tested to its theoretical limits to determine the ultimate strength of the structure. An initial operational capability was expected in 1972, but both the Army and Lockheed believed this might be advanced to as early as late 1970; this would prove to be hopelessly optimistic.<sup>4</sup>

A mockup inspection was held on 7 June 1966 with little comment. One of the changes requested involved the rear canopy, a change that

would create problems later. The rear cockpit used a one-piece sliding canopy, and a reviewer worried that when it was open, the pilot could stand up and be decapitated by the main rotor. The suggested solution, which was implemented, was to add two longitudinal bars across the top of the cockpit to prevent the pilot from standing up. The new helicopter was just over 60 feet long with a wing span of 26 feet 8.5 inches providing 130 square feet<sup>5</sup> of lifting surface. The main rotor had a diameter of 50 feet 4.8 inches and the anti-torque rotor was 10 feet in diameter. This made the aircraft the same basic size as a McDonnell Douglas F-4 Phantom II jet fighter.

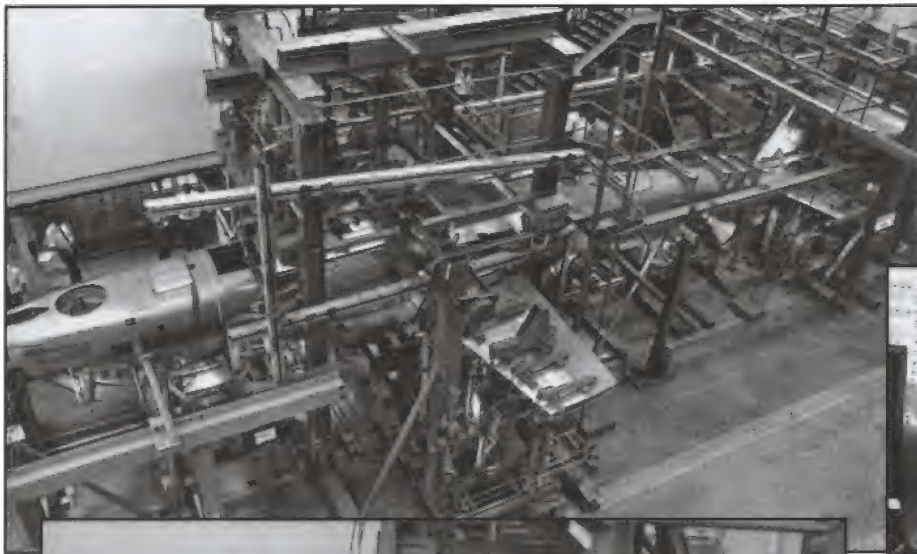
At the mockup inspection, Lockheed presented a maintenance concept that showed the AH-56A would require about the same maintenance as the much-less complex Hughes OH-6A. A maximum of 3.9 maintenance man-hours per flight hour was guaranteed by Lockheed. The engine could be removed in only 30 minutes, and the time between inspection was set at 300 hours, with 1,200 hours between major overhauls. Operational availability was estimated at 85 percent, with a 9 minute servicing time and 10 minute rearming time between combat sorties.

The AH-56As were assembled in Building 901 at Plant 8 in Van Nuys, California. The first aircraft (1001; 66-8826) was rolled out on 16 April 1967, and was named Cheyenne by the Chief of the U.S. Army Research and Development Command, Lt. General Austin Betts.

At the time the Army was anticipating that eventual production would



*One of the more obvious changes made during the mockup inspection was the addition to two cross bars over the pilot's cockpit to prevent the pilot from inadvertently standing up into the main rotor. This photo is of the fifth aircraft in 1968. (San Diego Aerospace Museum Collection)*



#1000 was a static test article that was used at Lockheed's Rye Canyon facility to determine the ultimate strength of the airframe. Its remains are currently at the Aberdeen Proving Grounds. (Lockheed)



The production of the ten prototypes took place in Building 901 at Plant 8 in Van Nuys, California. (Lockheed)

total between 500 and 1,000 Cheyennes and Lockheed prepared two pricing plans. The first was based on an accelerated production to be completed by mid-1971; the other would stretch production out until the end of 1972. Both included options for 375, 500, 1,000 and 1,500 aircraft. It is interesting to note that even at this early date the "best" price for production AH-56As was up to \$1,000,000 per copy.<sup>6</sup>

### FAA Certification?

Although it is becoming more popular today for the military<sup>7</sup> to require that aircraft be certificated by the civilian Federal Aviation Administration (FAA), this was an unheard of procedure in the 1960s. And it was not the Army, but Lockheed, that wanted to go through the pain of certificating the design. Lockheed's rationale was simple – the Cheyenne was to be the first mass-produced hingeless-rotor helicopter. A commercial derivative, the Model 1026 30-seat<sup>8</sup> civil transport, was already on the drawing

board. By certificating<sup>9</sup> the military AH-56A, Lockheed could greatly reduce the time and expense necessary to certificate the eventual civilian aircraft. FAA testing was scheduled to begin in July 1968, with Army service trials following in March 1969. The combined test program would take 1,000 hours involving six aircraft.<sup>10</sup>

The first Cheyenne (1001; 66-8826) was tied down in "Fort Cheyenne" – a circular stockade constructed of two heavy plank walls holding 8 feet of gravel between them. This was intended to contain a cata-

strophic rotor failure, should one occur, and also acted as a noise barrier since the tests were run around-the-clock. The first ground tests took place in May 1967, with the aircraft being used for engine and transmission endurance testing and dynamic response evaluations.<sup>11</sup>

During 1966, Lockheed had constructed a full-scale "whirl tower" in a natural bowl at Rye Canyon to test the structural integrity and hover performance of future helicopter rotors. The test facility could accommodate rotors for large transports; in fact, it was the largest



*The first Cheyenne (1001; 66-8826) inside Fort Cheyenne during August 1967. This airframe never flew, but was extensively tested at Fort Cheyenne and in the Rotorcraft Test Facility at Lockheed's Rye Canyon Research Center, a few miles north of Van Nuys. The thick walls of Fort Cheyenne were intended to contain any possible rotor failure, and also acted as a noise barrier for the surrounding community. (Lockheed)*



*The full-scale Whirl Tower was constructed in a natural bowl just outside the Rye Canyon Research Center. The large tower, left, is shown during April 1967 with one of the Model 286s flying overhead. (Lockheed)*



*The control room for the Whirl Tower, showing some of the consoles installed to support testing of the Cheyenne rotor system. This control room was considered state-of-the-art at the time. (San Diego Aerospace Museum Collection)*

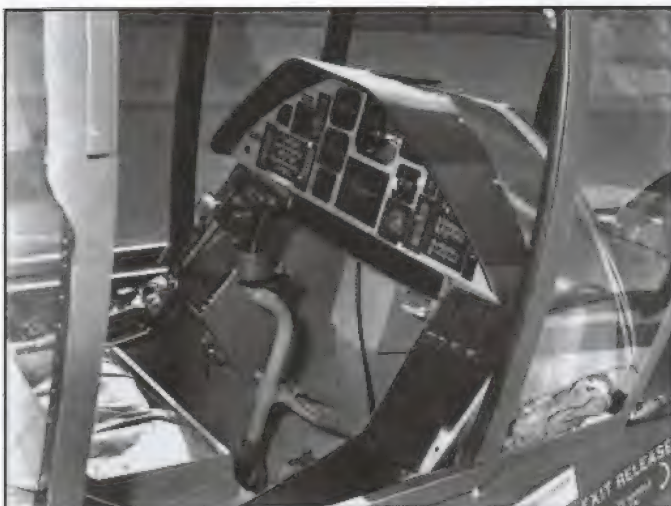


*Above: The Ground Test Vehicle (1001; 66-8826) poses with the second Model 286 (N286LC). (Lockheed)*



*Left: Externally, 1001 lacked the turrets and sensors along the lower fuselage, but was otherwise representative of later Cheyennes. (Lockheed)*

*Below: Since the aircraft did not carry a weapons system, the front cockpit of 1001 was not completed. The rear cockpit was not representative of the final configuration. (Lockheed)*



full-scale rotor test facility in the world. It would find extensive use refining the hingeless rotor concept for the Cheyenne.<sup>12</sup>

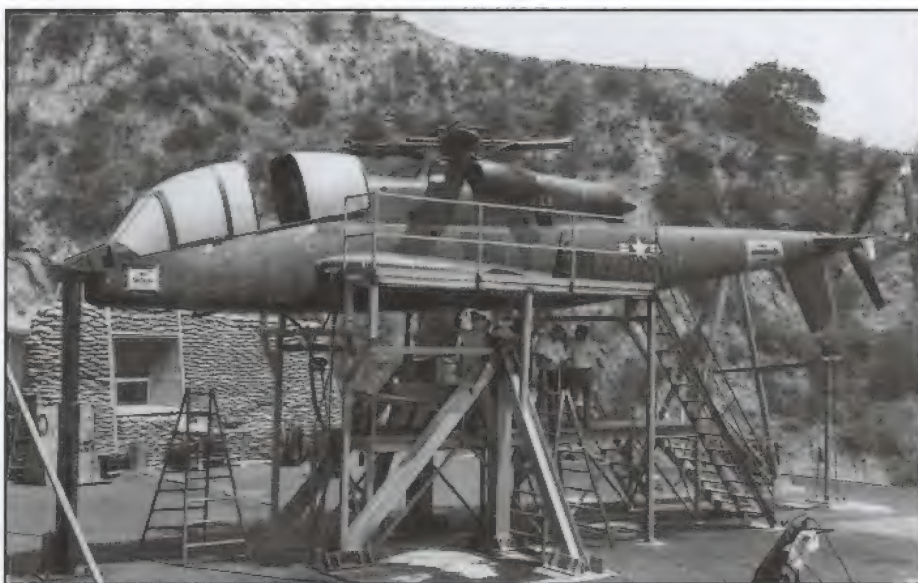
The AH-56A main rotor system was built around an electron-beam welded titanium hub that had to withstand the tremendous forces generated by the turning blades – forces that were normally absorbed by the hinges in an articulated rotor. Much of the titanium technology used in the hub had been generated by the Skunk Works during the A-12 Blackbird program. Each of the rotor blades was attached to a 3-foot titanium extension from the hub, and could rotate through 28° – 18° of collective pitch, 8° of cyclic pitch, and 2° of negative pitch while idling. But the blades could not flap up and down like a conventional articulated helicopter rotor.

The main rotor blades were manufactured by the Parsons Corp. and consisted of a Z-shaped titanium spar and leading edge wrapped with a titanium/stainless steel skin filled with an aluminum honeycomb core, all held together with a strong epoxy. The main rotor used 28-inch wide (chord) blades that tapered linearly in thickness from 12 percent at the root to 6 percent at the tip. The blades were swept-forward 4° and used a “droop snoot” airfoil optimized for high-speed flight. Centrifugal forces were carried by tension-torsion packs made up of 39,000 strands of high-tensile steel wire.<sup>13</sup>

In high-speed flight, the rotor could be completely unloaded from its lifting duties, but because of its hingeless characteristics it was still effective for pitch and roll control. Analysis showed, however, that completely unloading the rotor



*The Ground Test Vehicle (1001; 66-8826) installed on the hover rig at the Rotorcraft Test Facility. (San Diego Aerospace Museum Collection)*





*The top of the main rotor of Ship #1001 shows the three-foot titanium extensions that were bolted to the main hub. The rotor blades, in turn, were bolted to these extensions. This is the original (pre-ICS) rotor configuration. (Lockheed)*



*A bottom view showing the three-foot movable hubs and the location where the main blades bolt to them. Notice the difference in the gyro configuration, indicating this is an ICS-equipped aircraft. (Don Segner Collection)*



was not desirable. The rotor-wing combination had the least induced drag when operating as a biplane with the rotor carrying approximately 20 percent of the lift. The amount of lift carried by the rotor could be varied by the pilot's setting of the collective pitch.<sup>14</sup>

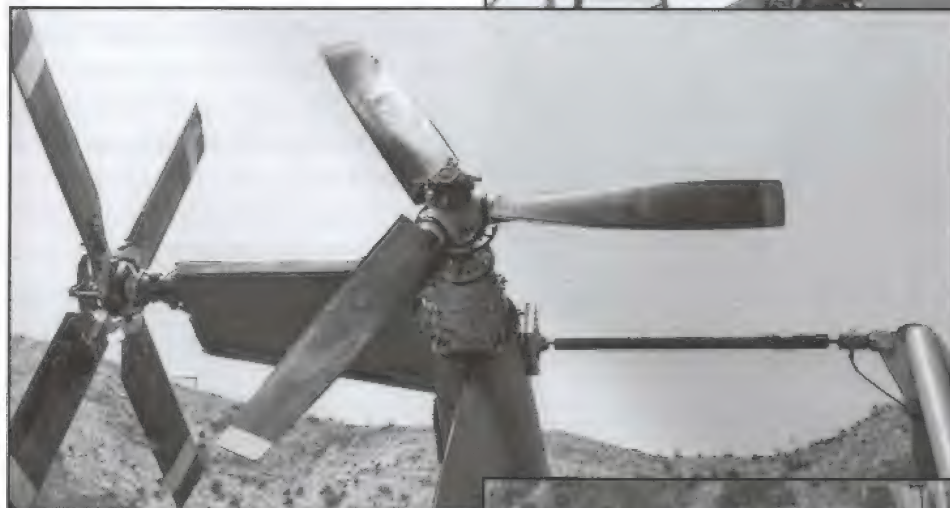
The main rotor shaft was 11.6 inches in diameter and was driven by a Kelsey-Hayes transmission system using double planetary gears.<sup>15</sup> The main rotor turned at a maximum of 246 RPM, which equated to a tip speed of 650 feet per second (445 mph), well below the speed of sound.<sup>16</sup> The anti-torque rotor had the same tip speed, but its smaller diameter meant it turned at 1,238 RPM. The anti-torque rotor was mounted on the left tip of the horizontal stabilizer in order to clear the arc of the propeller. The blades were untwisted and used a 6 percent airfoil.

The Hamilton-Standard pusher propeller was driven directly from the main transmission with a 5.5-inch thin-walled shaft turning at propeller RPM. It was designed to accept as much power as the engine could deliver; in fact, during high-speed flight only 300 hp was diverted to the main rotor, the rest being fed to the propeller as need-

*These are the two attachment points on a main rotor blade, manufactured by the Parsons Corp. (San Diego Aerospace Museum Collection)*

*The anti-torque rotor and pusher propeller on the first Cheyenne (1001; 66-8826). Note the exposed gearbox and how it drives both the pusher propeller and anti-torque rotor. (Lockheed)*

ed to maintain the desired forward speed. There was no way to disconnect the propeller from the drive system since the anti-torque rotor was also driven from the same source. The pusher propeller turned at 1,717 RPM with a tip speed of 900 fps (615 mph), dangerously close to the speed of sound under some atmospheric conditions. The pilot controlled the propeller pitch



*Two more views of the anti-torque rotor and pusher propeller on the Ground Test Vehicle. The pusher propeller was one of the key contributors to the Cheyenne's outstanding performance, and gave it capabilities no other helicopter could match. (San Diego Aerospace Museum Collection)*

directly with a twist grip on the collective lever. In hover, the propeller was normally set to a zero-thrust pitch<sup>17</sup> to conserve power, but it could be made to produce either positive or negative thrust. Operating the propeller in this manner could be used to change the hover attitude of the fuselage as much<sup>18</sup> as 18° – a useful feature when aiming rockets.<sup>19</sup>

One of the difficulties inherent in a compound helicopter is that when entering autorotation at high speed, the wing tends to produce so much lift that the rotor is starved





*A 16 April 1967 publicity photo of the first Cheyenne (1001; 66-8826) with one of the Model 286s hovering in background (top right corner). Herm "Fish" Salmon and Don Segner are in the cockpits of the AH-56A. (Lockheed)*

for the necessary thrust to keep it spinning. All the jet-powered compounds had special devices to reduce wing lift when going into autorotation to avoid this problem. The Cheyenne did not need such provisions. Instead, the pilot could reduce the pitch of the propeller, thus converting it into a windmill that extracted energy ("negative torque") from the passing airstream. This kept the entire drive system turning until the aircraft had slowed down to about 80 knots, at which speed it was put into a conventional autorotation. In fact, enough power could be extracted from the airstream at high speeds and extremely low altitude to allow the pilot to climb to a safe altitude before beginning the autorotation. Putting the propeller into negative-thrust pitch in flight was also a spectacular way to produce a rapid deceleration without the usual nose-up flare.



*Another 16 April 1967 publicity photo of 1001. Note the empty front cockpit and the lack of a belly turret. There are also no sensors under the gunner's station. The original sliding rear canopy is shown here. (Lockheed)*

## First Flight

When the Cheyenne contract had been signed, Lockheed had committed to a first flight on 22 September 1967. One day early, on 21 September, the second Cheyenne (msn 1002, 66-8827) made its maiden flight with Don Segner<sup>20</sup> at the controls. Lt. Colonel Kluever was in the front seat of an incomplete cockpit – there were no instruments or controls; in fact, shortly before the flight it did not even have a seat! During the 26-minute flight, Segner experienced a 45° cross-coupling of the controls, meaning the aircraft went 45° from where Segner was pointing it. Although somewhat unsettling for the duration of the flight, this was easily corrected after the flight by adjusting the orientation of the gyro.<sup>21</sup>

Soon, envelope expansion flights began from the airport at Van Nuys. Initial tests saw Segner flying the Cheyenne to speeds of 125 knots, totally within the confines of the Van Nuys airport. The propeller was used to brake the aircraft as needed to ensure it did not leave the relative safety of the airport. On 15 November 1967 the Cheyenne made its first cross-country flight, to the airport at Oxnard, California, which would serve as the major test location during the Lockheed tests. The aircraft flew at 115 knots and 2,000 feet with one of the Model 286s flying chase. Four Cheyennes could be housed in hangars at the test location, while sufficient ramp

*The "Aircraft Clearance Form" for the Cheyenne's first flight was signed on 21 September 1967. This form lists the c.g. (300 inches), gross weight (14,614 pounds), and passengers, as well as the takeoff and landing locations and times. (Don Segner Collection)*

space existed for five additional aircraft. The first three test flights from Oxnard were made later on the 15th, showing the basic reliability of the AH-56A even at this early stage of development.<sup>22</sup>

The Cheyenne was unveiled to the public during a 13-minute flight demonstration at Van Nuys on 12 December 1967. Don Segner maneuvered the third aircraft around the pattern, generally impressing all in the immediate vicinity. What was surprising is how quickly the flight envelope had been opened. Only 15 hours had

been logged by two flyable aircraft, yet the Cheyenne was cleared up to 170 knots and a bank angle of 30°. To the delight of the knowledgeable observers in the crowd, Segner held the Cheyenne in a steady hover during a 30 knot crosswind, then moved the aircraft forward and rearward without tilting the fuselage, using just the pusher propeller. At the end of the show, Segner landed but kept the tail wheel about five feet off the ground as he taxied back to the parking area, then slowly lowered the nose in a bow. This would become known as the "Cheyenne bob."

LOCKHEED - CALIFORNIA COMPANY A DIVISION OF LOCKHEED AIRCRAFT CORPORATION											
AIRCRAFT RELEASED FOR:						AIRCRAFT CLEARANCE					
PRODUCTION						TEST FLIGHT					
ENGINEERING						DELIVERY FLIGHT					
LAS						SPECIAL FLIGHT AS INDICATED					
WORK ORDER NUMBER						FLIGHT NUMBER					
F.O. C.G.		GR. WT.		L.O.C. C.G.		GR. WT.		TOTAL GALS. GAS		TOTAL GALS. OIL	
300 INCHES		14,614									
FUEL DISTRIBUTION											
TANK		AMOUNT		TANK		AMOUNT		TANK		AMOUNT	
1120W		1250 MGAGE									
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<small>Inspection, Adjustments and Testing Only: "Beak" completed and Approved for Flight</small> <small>DATE: 9/21/67 TIME: 14:00 SIGNATURE: [Signature]</small>											
<small>FLIGHT CLEARANCE: THE CRAFT'S WEIGHT-OR SEQUENCE HAS BEEN CHECKED BY THE UNDERSIGNED WHO AGREES THAT CONDITIONS AND WEATHER ARE SUITABLE FOR COMPLETION OF THIS FLIGHT AS PLANNED. WEATHER IN ALL ASSIGNED AREAS IS APPROVED FOR FLIGHT.</small>											
CREW AND PASSENGERS						DISPATCHER					
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		CL KLUEVER	CO-PILOT		9/21-67						
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						D. SEGNER					
						420114					
						MODEL					
						AH-56-A					
						LICENSE					
						ARMY					
						TYPE OF FLIGHT					
						TAXI TEST 3 FIRST FLIGHT					
						TAK OFF POINT					
						VNY					
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						VNY					
						LANDING TIME					
						17:44					
						TAKE OFF TIME					
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						FLIGHT TIME					
						:26					
						LANDINGS					
						NIGHT					
						DAY					
						APPROACHES					
						ILS					
						RANGE					
						INSTRUMENT TIME					
						ACTUAL					
						HROD					
						PILOT					



*The first flight of a Cheyenne took place on 21 September 1967 using the second aircraft (1002; 66-8827) with Lockheed test pilot Donald R. Segner at the controls and Army project manager Lt. Colonel Emil "Jack" Kluever in the incomplete front cockpit. The flight lasted 26 minutes. (Lockheed)*



*Another shot of the first flight. (Lockheed)*

*Group photo taken after the first flight on 21 September 1967. (Don Segner Collection)*



*Few photos exist of the Cheyenne carrying external fuel tanks. These photos, taken at various times, show Ship #1002 (66-8827) with a tank on each outboard wing pylon. Note the 2.75-inch FFAR pods on the inboard wing pylon (below). Test pilot Don Segner is standing next to the aircraft in the center photo. (Lockheed via the Don Segner Collection)*



## Trouble in Paradise

Although the early flight program was progressing well, the business side of Cheyenne was not. It was ironic that the war in Southeast Asia was driving the need for the AH-56A, but at the same time it was absorbing all the Department of Defense money that was usually allocated to development projects. At the time the Cheyenne found itself to be in the same position as the General Dynamics F-111 and Lockheed C-5 Galaxy – essentially an experimental contract under the new procurement rules dictated by Robert McNamara. The way the contract was written, development and production were lumped together.

In the case of Cheyenne, the contract with Lockheed specified that a production order would be forthcoming by the end of 1967. If not,

then Lockheed would be free to renegotiate the price; and there was no doubt the unit cost would increase substantially. The Army asked McNamara to approve FY68 funds for production, but the Secretary turned the request down, indicating that production would have to wait until FY69. So the Army began looking internally for funds that could be reallocated from existing projects, something made more difficult by the need to purchase equipment and materiel for the war.

Another rift arose over the way Lockheed had provided production cost estimates. Instead of quoting a price per aircraft on a sliding scale (as production quantities increase, unit cost usually goes down), Lockheed had quoted unit costs based on four different production quantities – 375, 500, 1,000 and 1,500 aircraft. If the Army wanted to pur-

chase 600 aircraft, they paid the same unit cost as if they had bought 500. This matter was never settled since the Army had approved the original contract that had contained the four-level pricing structure.<sup>23</sup>

On 8 January 1968, the Army finally scrapped together \$21.4 million by raiding other accounts and allocated it to the Cheyenne program for pre-production planning, engineering, and procurement of long lead-time items. A gentleman's agreement between Lockheed and the Army had extended the 31 December 1967 deadline when it became obvious the Army would ultimately find the money. As one of his last actions before leaving office, McNamara approved the release of the funds. Actually authorizing full-scale production would fall to the new Secretary of Defense, Clark Clifford, at some later date. At the time, the commander of the Army Materiel Command, General Frank Besson, Jr., said: "Actual flyaway cost is dependent upon the quantities that would be produced. ... But, in general, a million dollars is the ballpark fly-away cost which includes everything in the aircraft that the pilot needs to provide the complete weapons system."<sup>24</sup>



*Two inflight views of Ship #1002 (66-8827) during the early test program. Note the air data probe protruding from the nose in the photo at right. The Cheyenne looked particularly sleek without the belly turret and sensor package. The exhaust from the T64 engine deposited a great deal of soot on the rear fuselage before the IR trough was added. (Lockheed)*



Manufacture of the first production AH-56A was now scheduled to begin on 20 September 1968, with the first delivery being one year later. Lockheed planned to manufacture subassemblies for the Cheyenne at both Van Nuys and Burbank, then to perform final assembly at Air Force Plant 42 in Palmdale, California. Although the Army still expected to procure 600 Cheyennes, the lack of funds had forced them to sign onto the program at the 375 aircraft level, meaning each production aircraft would cost more than it should have under a different contract structure. But a huge battle had been won just by getting this far. The Air Force had been lobbying to cancel the AH-56A contract based on it being too close in function to the upcoming A-X close air support aircraft (which eventually became the Republic A-10 Thunderbolt II). Congress and the Department of Defense had sided with the Army, at least for now.

By this time, the test program had logged 20 flight hours, and by the end of January were joined by the fifth aircraft. As in most every flight test program, each prototype was assigned specific tasks. The first airframe (1000) was a structural test article, and would never fly. The first real aircraft (1001; 66-8826) was the Ground Test vehicle, and also would never fly. The second aircraft (1002; 66-8827) was dedicated to opening the flight envelope, conducting rotor stress tests, and defining emergency flight procedures (autorotation characteristics, etc.).

*The third Cheyenne (1003; 66-8828) under construction during August 1967. Like the first two aircraft, it was equipped with the sliding rear canopy. (Lockheed)*



*The second (top) and third (1003; 66-8828) Cheyennes fly in formation over Southern California. (Lockheed)*

For this role it did not need any of the weapons system or advanced avionics. The third Cheyenne (1003; 66-8828) was extensively instrumented to measure flight loads, engine and transmission performance, and handling qualities. The fourth AH-56A (1004; 66-8829) had

a developmental weapons system, and was used for most early weapons testing at the Potrero Range, near Redlands, California. The fifth aircraft (1005; 66-8830) had a complete avionics system and was dedicated to testing it. The five remaining aircraft were finished to





Several views of the third Cheyenne (1003; 66-8828). The photo at right shows 1003 performing engine tests at Oxnard on 6 March 1968. Note the air data probe on the nose. The photo at bottom was taken during 1003's first public display on 12 December 1967. This was the only aircraft that used a white outline around the ARMY on the fuselage.

The leading edge of the "C" in Cheyenne on the forward fuselage had a "feather" motif. (Lockheed)





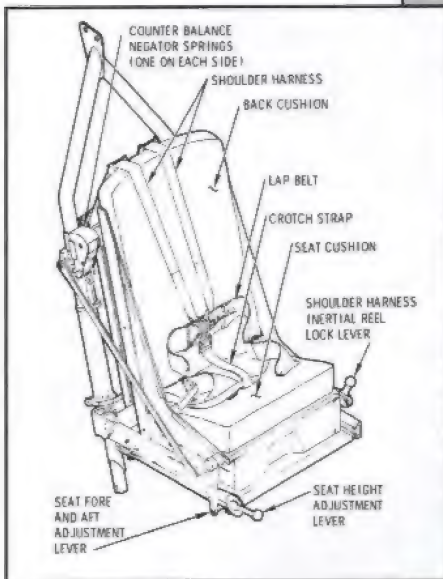
*Ship #1004 during its first public display at Van Nuys, on 12 December 1967. An XM-196 six-barrel minigun was installed in the nose turret. The 7.62-mm minigun was capable of delivering suppressive fire at selected rates of 750, 1,500, 3,000, or 6,000 rounds per minute. A complete sensor assembly is also visible beneath the fuselage. (Lockheed)*

*The Weapons Integration Vehicle (1004; 66-8829) being lifted onto the weapons test platform at Portrero, California, on 29 May 1968. This aircraft spent its entire career at this facility, and never flew. (Lockheed)*





The fifth AH-56A (1005; 66-8830) was the Avionics Integration/Development vehicle, and flew primarily out of the Oxnard test location. This was the first Cheyenne equipped with the complete Integrated Helicopter Avionics System. The vertical, wing tips, and broad strip around the fuselage were bright orange. (San Diego Aerospace Museum Collection)



A close look at the pilot's station shows both the collective lever (at the very bottom) and the cyclic control stick. (San Diego Aerospace Museum Collection)



pre-production standards that included the weapons and avionics systems. These aircraft were used for additional weapons trials, FAA and Army certification tests, reliability and maintainability testing, performance testing, environmental tests, and operational evaluations.

By March 1968, the Cheyenne had demonstrated a forward speed of 170 knots, sideward flight of 25 knots, and rearward flight of 20 knots. The aircraft was cleared to maneuver at +1.6-g. Several minor problems had been uncovered, including the need for harder mounts for the pusher propeller gearbox and slightly different weights on the propeller blades to change their natural frequency. The rear cockpit canopy vibrated irritatingly, so the frames were stiffened and a new latching mechanism was

fitted, but this did not totally solve the problem. It was subsequently discovered that what was vibrating were the two bars that had been added across the top of the canopy opening during the mockup review.

### A Change in Expectations

The Cheyenne had been conceived as a high-speed escort for troop helicopters, primarily the CH-47 Chinook. But the aircraft that Lockheed was building was capable of much more. Army commanders began, informally at least, developing concepts that used the Cheyenne in direct fire-support roles. This was understandable. Most close air support was provided by fixed-wing aircraft that could not fly low and slow enough to engage some of the targets the field commanders needed destroyed. The aircraft also had

to leave the battlefield frequently to return to a friendly base to refuel and rearm. The AH-1 Cobra<sup>25</sup> was proving to be a valuable asset, but it did not carry enough weapons, lacked a sophisticated fire control system, and had a limited range. The Cheyenne could change all of this.

With a mission endurance of 2.5 hours on station (plus 30 minutes transit time), the AH-56A could provide support for troops throughout a battle. At 2,000 feet elevation on an 80°F day the Cheyenne could carry 2,100 pounds of ordnance – usually listed as 2,010 rounds of 30-mm, 780 rounds of 40-mm, six BGM-71 TOW anti-tank missiles, and two 2.75-inch rocket pods (38 rockets). Even in the heat and humidity of Southeast Asia this weapons load would only be reduced by the TOWs.



*The sixth Cheyenne (1006; 66-8831) at Portrero during weapon firing tests on 27 August 1968. This was the primary aircraft used for testing the Swiveling Gunners Station and the Pilot Helmet Sight. Note the 7.62-mm minigun in the nose turret. (Lockheed)*

This would provide tremendous firepower under the direct command of the troops on the ground. The inclusion of the TOW system made the AH-56A, at least in theory, capable of destroying tanks and other armored vehicles in any possible European combat scenario. The advanced weapons system included a magnifying sight that allowed the Cheyenne to stand-off at a safe distance, observing the enemy from long range. A laser rangefinder and moving map display allowed the gunner to pinpoint the location of targets and relay this information to artillery batteries behind the front line. Hughes Aircraft was providing passive infra-red night equipment (PINE) that would be installed in the rotating sight. This would be the first IR<sup>26</sup> sensor produced for an operational aircraft, and provided night and limited all-weather capabilities. Alternately a group of Cheyennes could operate as a fire team, capable of destroying most targets by themselves. The weapons system allowed the AH-56A to track and attack a target while maneuvering, unlike the Cobra that had to come nearly to a stop to engage targets accurately. It was quickly becoming apparent that the Cheyenne would bring an entirely new dimension of Army tactics and doctrine, perhaps even challenging the dominance of the tank on the battlefield. But first, it would have to enter production.

### Advanced Weapons System

The original AAFSS specification had called for the ability to fire accurately down one side of the aircraft as it passed perpendicular to a target at full speed. This was a revolutionary requirement for 1960s technology, and drove an extreme-

ly advanced sensor and fire control system for the AH-56A. To find and identify targets, the Cheyenne was equipped with a magnifying optical sight under the forward fuselage, in front of the ventral gun turret to avoid blinding the optics with muzzle flashes. The gyro-stabilized sight was viewed by the gunner using a periscope, and had three possible magnifications: 1.5X, 4.2X, and 12X. The platform for the sight also incorporated a laser rangefinder, the PINE sensor, and TOW guidance equipment. Once a target was designated by the gunner, the fire control system automatically tracked it, even if it was no longer in direct view.

A great deal of thought went into the design of the Cheyenne cockpits, which were undoubtedly the most complicated helicopter cockpits yet designed. A mixture of conventional round instrumentation, tape-style<sup>27</sup> instrumentation, and a electronic display (CRT) were used to present information to the pilot and gunner. In fact, the AH-56A was the first military aircraft to use a CRT to present information in the cockpit.<sup>28</sup>

The flight controls were generally similar to a normal helicopter. Rudder pedals were linked to the anti-torque rotor, and a cyclic control stick provided pitch and roll control. A collective was used at lower speeds for altitude control. Trim was accomplished conventionally with the cyclic and rudder pedals. A twist grip on the collective (called a beta control) controlled the amount of power transferred from the main rotor to the propeller. The beta control was separate from the normal twist-style throttle, also located on the collective. A beeper switch on the end of the collective set the

main rotor speed, which was then automatically maintained.<sup>29</sup>

Perhaps the most interesting design detail in the Cheyenne was reserved for the gunner in the front cockpit. The gunner sat on an XM-112 stabilized gunner station (SGS) that could rotate through 210° on either side of the centerline as the gunner tracked a target. As the seat rotated, so did whichever turret the gunner was using. This novel system was designed by the General Electric Avionics Controls Division. The SGS was space-stabilized to allow the gunner to concentrate on a given target independently of aircraft motion. The seat was also equipped with a fast pivot that allowed the gunner to quickly turn to face the opposite direction. A binocular eyepiece was mounted at the top of the console on the seat platform, and control grip handles at either side of the console contained most of the controls for designating, ranging, and weapons firing. The gunner's position also contained a redundant set of flight instruments, plus fold-away collective and cyclic side-arm controllers that allowed the gunner to fly the helicopter. Logic in the control system would not allow the gunner to take over unless his seat was facing forward and locked down. The upper portion of the weapons console and periscope were designed to swing downward to allow the gunner to see his flight instruments.<sup>30</sup>

The pilot also had a sighting system that was years ahead of its time. The Honeywell visual precision fire control equipment (VIPRE) was designed to fit over the standard APH-5 helmet. Nylon screws held the 22-ounce sight to the helmet,



*Two Cheyennes pose for a weapons display in February 1971. The white 2.75-inch rockets are at the bottom, followed by six TOW missile rounds, and 30-mm and 40-mm ammunition. (Lockheed)*



*The rear (pilot's) cockpit of Ship #1005 (66-8830) prior to delivery on 15 February 1968. The large paper map display is located in the center pedestal, with the weapons control panel directly above it. The vertical part of the right console has caution and warning lights at the top, and radio controls at the bottom. The right console itself has controls for the computer system. Note the mixture of conventional (circular), vertical, and horizontal "tape" instruments on the main panel. (Lockheed)*

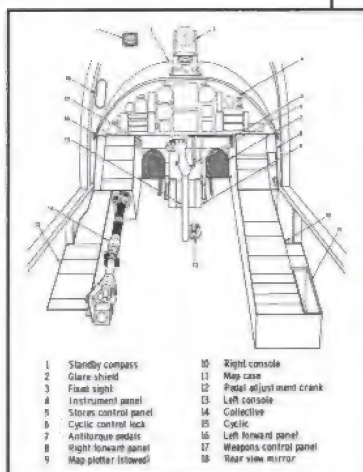
*The front (gunner's) cockpit of Ship #1005 prior to delivery. The large paper map display is located on the front instrument panel, mostly obscured by the large pedestal sight and weapons control panel. The eyepiece for the periscopic sight is visible. Note the pistol grip beside the weapons control panel. (Lockheed)*



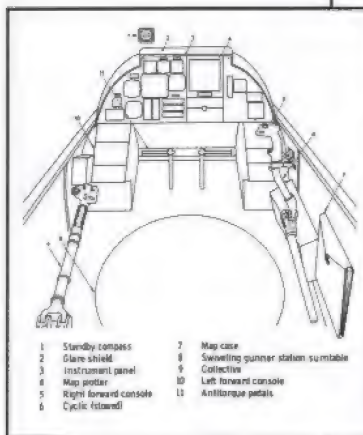
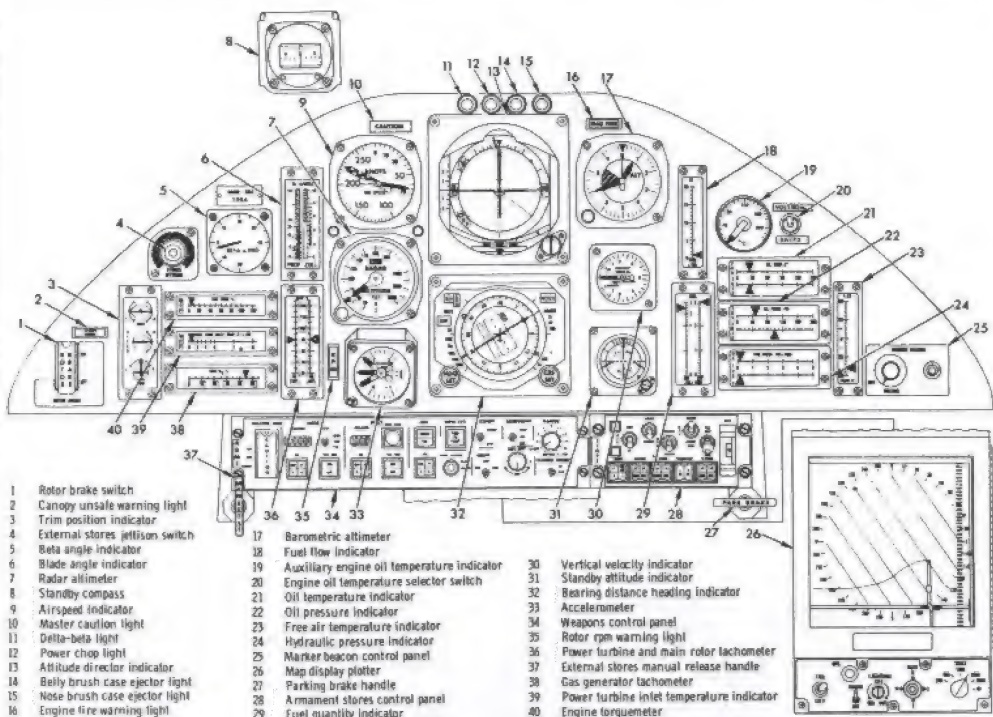
designed to break off in any severe impact to avoid neck injuries to the pilot. An electrical cord provided power to the sight, and helmet motion was tracked by photodetectors mounted in the cockpit. The main part of the sight projected in

front of the pilot's head and incorporated a projector with a drop-down combining reticule over one eye.<sup>31</sup> The fire control system used information on where the pilot was looking to determine the correct aim angles, offset points, lead, and

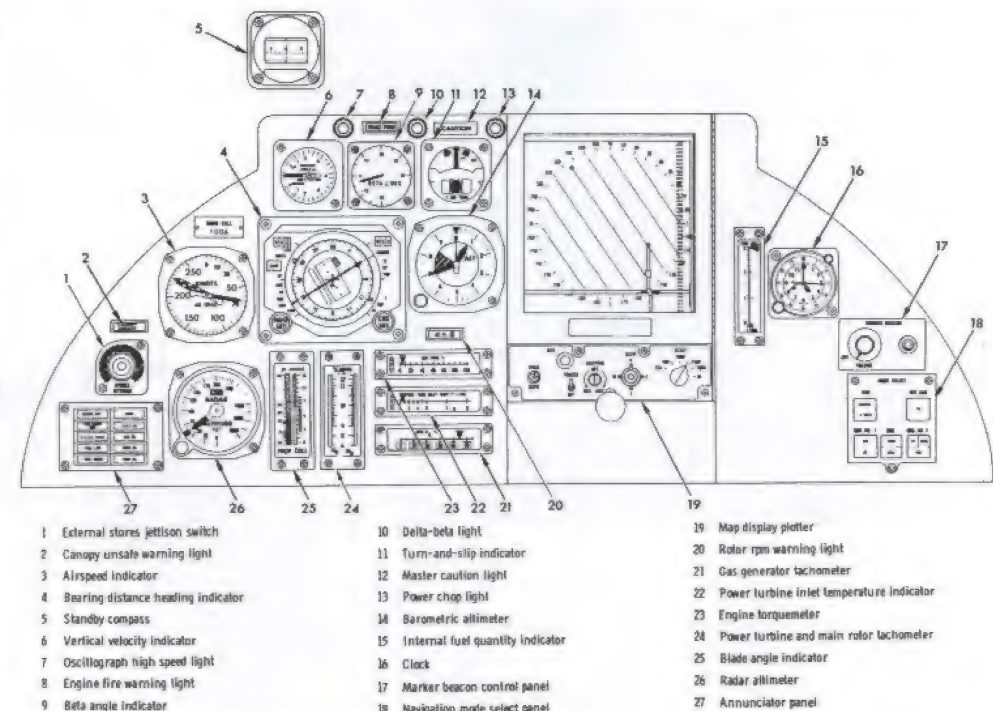
drop for either turret. The pilot could also direct the weapons system to "command swivel" the gunner to point at a target the pilot had located; what effect this unexpected movement had on the gunner has gone unrecorded.<sup>32</sup>



*The pilot's instrument panel. (U.S. Army)*



*The gunner's instrument panel. (U.S. Army)*



## Armament

A single turret was mounted in the extreme nose and could elevate 18°, depress 70°, and rotate 200° in azimuth. A single Philco Ford Aeronutronic XM-129 40-mm grenade launcher with 780 rounds of ammunition was usually carried. The grenade launcher could fire 350 rounds per minute, and had an effective range of approximately 1,640 feet. Initial plans were to allow the grenade launcher to be interchanged with an XM-196 7.62-mm minigun, but these were dropped later in the program.

An XM-52 turret was installed under the mid-fuselage and contained a Philco Ford XM-140 30-mm cannon. The cannon could elevate 26°, depress 60°, and could be rotated 200° on either side of the centerline

(providing 360° coverage). Automatic limit switches prevented the cannon being aimed at any portion of the aircraft, such as the vertical stabilizer. The main fuselage held 2,010 rounds of 30-mm ammunition. The cannon could fire 400 rounds per minute, and had an effective range of almost 10,000 feet.

All of these guns encountered development problems, not uncommon for any new weapon. The 7.62-mm minigun was prone to jam, although in one demonstration it managed to fire 269 rounds, scoring 237 hits on the target. Eventually the problems were worked out, but the minigun was not included in the final production configuration. The 30-mm also experienced jamming problems, approximately every 2-3 rounds during its early development. Extensive efforts ini-

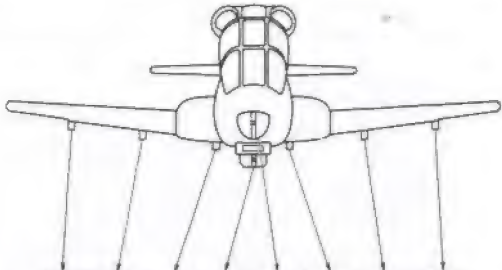
tially reduced the jamming to every 25-30 rounds, and eventually to every 3,000+ rounds.

Each of the wings had two hard-points capable of carrying 2,000 pound each, and two additional hard-points were located under the fuselage sponsons. The sponson stations were limited to carrying auxiliary fuel tanks, but the wing pylons could carry an assortment of fuel tanks, rocket pods, or TOW missiles. With little doubt additional weapons, such as bombs, cluster munitions, and napalm would have been integrated once Cheyenne entered service.

The mid-1960s was the beginning of a technology revolution, and Lockheed proposed various enhancements for the Cheyenne. Some of the more interesting pro-



*The nose-mounted XM-196 six-barrelled 7.62-mm minigun. This weapon was deleted from the expected production configuration because of development problems (which were subsequently overcome), but was tested extensively nevertheless. (Lockheed)*



	OUTBOARD WING	INBOARD WING	FUSELAGE	BELLY TURRET	NOSE TURRET	FUSELAGE	INBOARD WING	OUTBOARD WING
XM-129 40 MM GRENADE LAUNCHER OR XM-196 7.62-MM GUN					780 ROUNDS 13,750 ROUNDS			
XM-140 30-MM GUN				2030 ROUNDS				
TOW MISSILES		3					3	
	450 GAL DROP TANK	450 GAL DROP TANK				300 GAL TANK	450 GAL DROP TANK	450 GAL DROP TANK
ROCKETS 2.75-IN. FFAR	X	X					X	X
TOW MISSILES		X					X	
TRIPLE ADAPTER RACK UP TO 2000 LB STORE	X	X	X			X	X	X

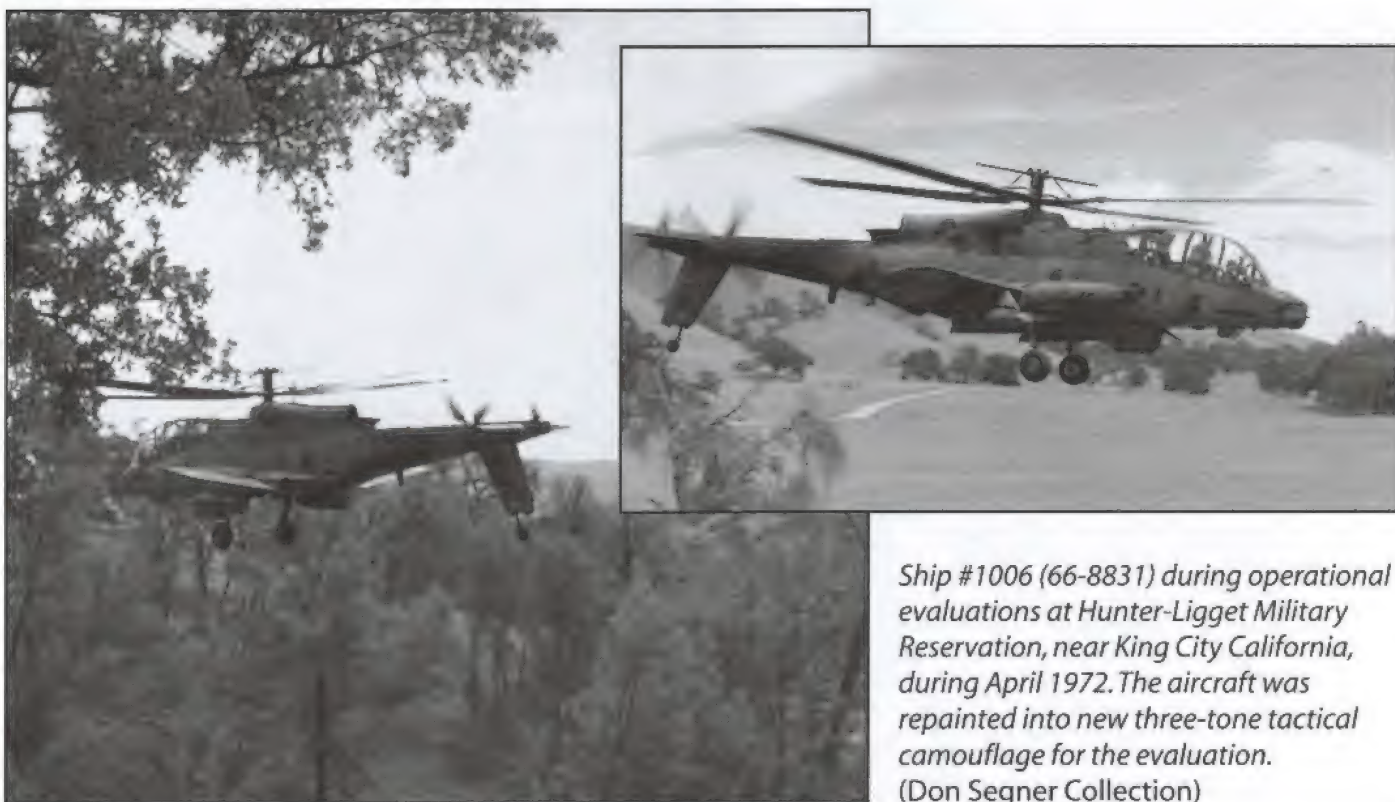
**NOTE**

- THE INBOARD AND OUTBOARD WING PYLONS CAN BE MODIFIED TO CARRY A VARIETY OF EXTERNAL WEAPONS AND STORES
- FUEL TANKS MAY BE INSTALLED ON ANY FIVE OF THE SIX PYLON STATIONS. THE 300-GALLON FUEL TANK MAY BE CARRIED AT EITHER FUSELAGE STATION

*The weapons carriage chart from the flight manual. (U.S. Army)*

posals included an electronic moving map display (to replace the paper one), Doppler/INS navigation equipment, a five-axis automatic flight control system, various electronic countermeasure (ECM) systems, a station-keeping radar for all-weather formation flying, low-light television equipment, and a terrain-following radar mounted in a pod on one of the sponson stations. Perhaps the most interesting proposal was for an active night-vision system using a low-power laser that would illuminate the battlefield.<sup>33</sup>

<sup>1</sup> Foreman, Brenda Dr., *What Killed the Cheyenne*, *VertiFlight*, Vol. 42 No. 3, May/June 1996, p. 25. <sup>2</sup> Allen, Francis J., *Cheyenne*, *Wings*, October 1995, p. 46. <sup>3</sup> No evidence was uncovered that supported some references to these aircraft as YAH-56As. <sup>4</sup> Hewson, Robert, *Beyond the Frontiers: Lockheed AH-56 Cheyenne – The Lost Tribe*, *Wings of Fame*, Vol. 14, AIRtime Publishing Inc., 1999, p. 143. <sup>5</sup> During the test program this would be increased to 195 square feet by extending the chord. <sup>6</sup> Hewson, Robert, *Beyond the Frontiers: Lockheed AH-56 Cheyenne – The Lost Tribe*, *Wings of Fame*, Vol. 14, AIRtime Publishing Inc., 1999, p. 145. <sup>7</sup> Today, most of the military's trainers and cargo aircraft are certificated by the FAA. In part this was due to acquisition reforms that attempted to ease the burdens on the aircraft manufacturers by making them test aircraft to a single standard. Since most of the aircraft in these categories are derivatives of civilian models, this makes good economic sense. <sup>8</sup> A larger, 90-seat, Model 1090 variant was also being considered. <sup>9</sup> The FAA certificate awarded to the Model 286 was not directly applicable to the Model 1026 or Cheyenne. The 286 had weighed only 4,000 pounds – less than 25 percent of the weight of the new aircraft. <sup>10</sup> Hewson, Robert, *Beyond the Frontiers: Lockheed AH-56 Cheyenne – The Lost Tribe*, *Wings of Fame*, Vol. 14, AIRtime Publishing Inc., 1999, p. 145. <sup>11</sup> Prouty, Ray W. and Yackle, Al R., *The Lockheed AH-56 Cheyenne – Lessons Learned*, AIAA Document 92-4278, presented at the AIAA Aircraft Design Systems Meeting, 24-26 August 1992, Hilton Head, S.C., p. 7. <sup>12</sup> Lockheed video, *Testing the AH-56A Cheyenne*, 1969. <sup>13</sup> *Jane's All the World's Aircraft*, 1971-72, p. 366. <sup>14</sup> Prouty, Ray W. and Yackle, Al R., *The Lockheed AH-56 Cheyenne – Lessons Learned*, AIAA Document 92-4278, presented at the AIAA Aircraft Design Systems Meeting, 24-26 August 1992, Hilton Head, S.C., p. 5. <sup>15</sup> *Jane's All the World's Aircraft*, 1971-72, p. 366. <sup>16</sup> At the speed of sound a helicopter rotor suffers the same effects as an aircraft wing – drag increases radically and a large change in pitching moment develops. This tends to cause the rotor blades to twist unpredictably, causing a loss of lift and control. In general, helicopter designers try to avoid having the rotors approach critical Mach number, although the advent of modern composite-rotor blades has somewhat eased the problem because composite blades are orders of magnitude stiffer. <sup>17</sup> Usually reported as "zero pitch" but in reality the blades were still at an angle, they were just not producing any thrust. <sup>18</sup> Most sources report 10° – but Don Segner remembers using 18-20° on a routine basis. <sup>19</sup> Prouty, Ray W. and Yackle, Al R., *The Lockheed AH-56 Cheyenne – Lessons Learned*, AIAA Document 92-4278, presented at the AIAA Aircraft Design Systems Meeting, 24-26 August 1992, Hilton Head, S.C., p. 6. <sup>20</sup> In addition, Segner had been the first to fly the XH-51A, the first to fly the Model 286, and the first to fly the XH-51A Compound. <sup>21</sup> Hewson, Robert, *Beyond the Frontiers: Lockheed AH-56 Cheyenne – The Lost Tribe*, *Wings of Fame*, Vol. 14, AIRtime Publishing Inc., 1999, p. 146. <sup>22</sup> Video documentary, *Project Cancelled: AH-56A Cheyenne*, Lianishen Films LLC, 1998. <sup>23</sup> Hewson, Robert, *Beyond the Frontiers: Lockheed AH-56 Cheyenne – The Lost Tribe*, *Wings of Fame*, Vol. 14, AIRtime Publishing Inc., 1999, p. 146. <sup>24</sup> *Military Report*, *Air Progress*, April 1968, p. 24. <sup>25</sup> The HueyCobra name quickly gave way to just Cobra. <sup>26</sup> This is usually termed a forward-looking infrared (FLIR), but this is somewhat inaccurate since the sensor could rotate through 360° on the Cheyenne. <sup>27</sup> Tape instruments were very much in vogue during the late 1950s and early 1960s. By presenting a moving "tape" against fixed reference points, it was believed the pilot could be shown actual and preplanned information quickly and accurately. This style of instrumentation was found in many high-performance aircraft of the period. <sup>28</sup> Hewson, Robert, *Beyond the Frontiers: Lockheed AH-56 Cheyenne – The Lost Tribe*, *Wings of Fame*, Vol. 14, AIRtime Publishing Inc., 1999, p. 149. <sup>29</sup> *Lockheed Unveils Rigid-Rotor AH-56A*, *Aviation Week and Space Technology*, 8 May 1967, pp. 25-26. <sup>30</sup> POMM 55-1520-222-10, Preliminary Operational/Maintenance Manual for the Helicopter, Attack, AH-56A (Lockheed), July 1971, p. 6-80. <sup>31</sup> The reticule could be set up for either eye, based on the pilot's preference. <sup>32</sup> Hewson, Robert, *Beyond the Frontiers: Lockheed AH-56 Cheyenne – The Lost Tribe*, *Wings of Fame*, Vol. 14, AIRtime Publishing Inc., 1999, p. 149. <sup>33</sup> *Ibid*, p. 153.



Ship #1006 (66-8831) during operational evaluations at Hunter-Liggett Military Reservation, near King City California, during April 1972. The aircraft was repainted into new three-tone tactical camouflage for the evaluation. (Don Segner Collection)



*A 1970 series illustrating a TOW missile being fired and about to impact a tank at Yuma Proving Grounds. (Lockheed)*



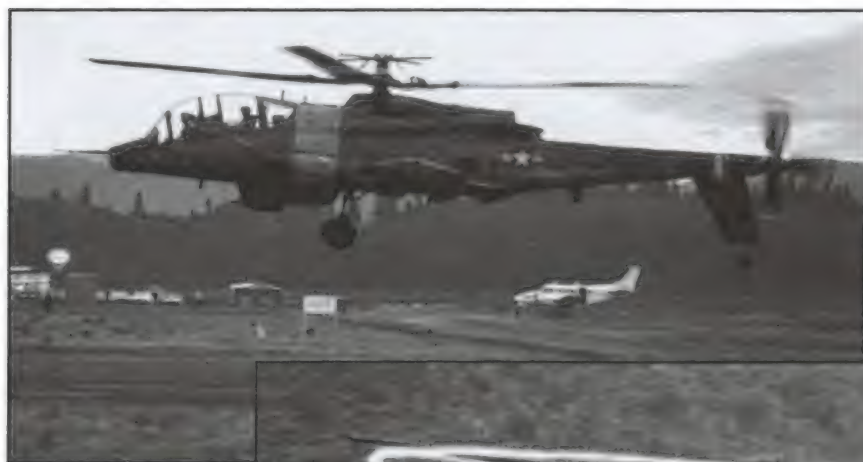
*An aerial view of gun test facility at Portrero, California, with one Cheyenne on the hardstand. (Lockheed via the Don Segner Collection)*



*The weapons test vehicle (1006; 66-8831) in flight with TOW pods on the inboard pylons. The front and rear covers on the TOW pods are painted orange, explaining their light-color appearance here. (Lockheed)*



*Landing gear fully extended, a Cheyenne is ready to land. Note the full extension on the tail wheel. (Lockheed)*



*The only time three of the Cheyennes were photographed together in flight was in February 1969. The far aircraft is Ship #1002 with Don Segner at the controls. Ship #1003 piloted by Ray Goudey is in the middle. The aircraft in front is #1005 with Dave Beil and Jim Upton in the cockpit. (Lockheed)*

Above and right:

*Ship #1009 at Mammoth Lake airport during high altitude testing on 9 June 1972. (Lockheed)*

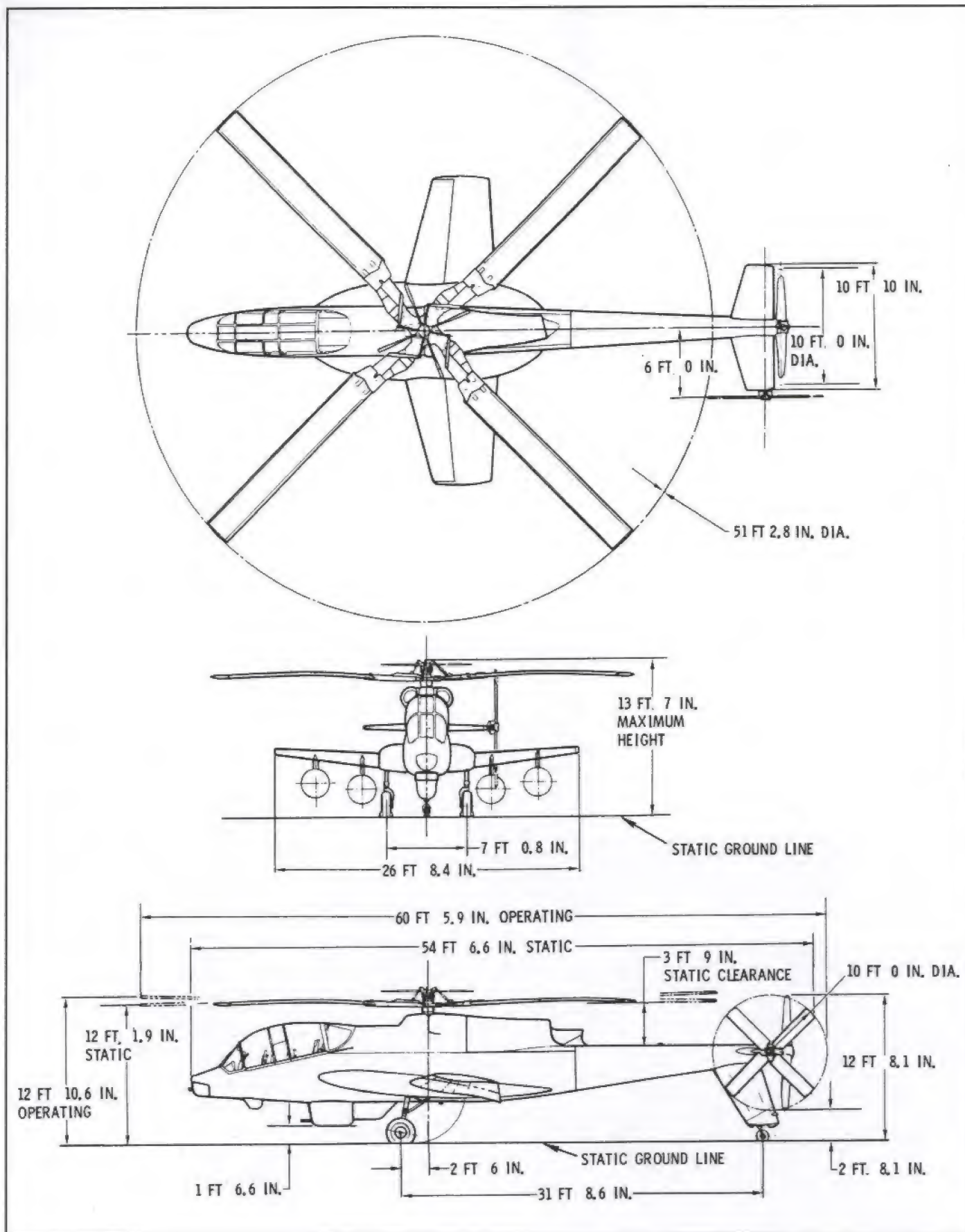


*The last Cheyenne (1010; 66-8835) traveled to Canada, for cold weather testing during February 1969. As if the weather was not cold enough, a giant snow machine was used to blow snow and ice over the Cheyenne while Don Segner flew through it. (Lockheed)*



*Note the Indian Head logo in the photo above. The tenth aircraft was the only one so painted. The Cheyenne passed its cold weather experience without incident. (Don Segner Collection)*





Three-view drawing and dimensional data from the flight manual. (U.S. Army)

# THE LOST TRIBE

## THE LOCKHEED HELICOPTERS

**L**ockheed only built 16 helicopters: a single CL-475, two Model 286s, three XH-51s, and ten Cheyennes.

Even the little CL-475, never intended as anything but a proof-of-concept vehicle, looked streamlined and fast for its day. A very civilian-looking white paint scheme with gold and red trim gave it the appearance of wanting to go home to your garage; to be your daily transport.

The Model 286s were intended for the civilian market and would look perfectly at home at any executive airport. Their speed and stability was exceptional, but only the two prototypes were built.

The XH-51s are still some of the prettiest helicopters ever manufactured. Again, Lockheed made them look modern and streamlined; a look they

retain even 30 years later. The fact that they are still amongst the fastest helicopters ever built is testimony to the capabilities of Lockheed's hingeless rotor system.

And then there was Cheyenne. Fast, deadly – the very essence of a gunship helicopter. But, sadly, it too was not to be, and only ten aircraft were manufactured.



*The CL-475 with the original two-bladed main rotor hovers at Rosamond Dry Lake, north of Los Angeles. Note the very streamlined rotor hub. (Lockheed)*

*Yes, it was a publicity stunt. Lockheed used the first XH-51A (BuNo 151262) to demonstrate the stability of the hingeless rotor, even with large offset loads. Once trimmed, the aircraft could be flown hands-off for short periods in this configuration. Dick Cotton is in the chair and Don Segner is at the controls in this 10 September 1963 photo. (Lockheed)*

*Cheyenne*



The XH-51A Compound (BuNo 151263) shows the original forward canopy configuration. Another brace was later added towards the bottom of the canopy to keep the plexiglass from bowing in during extremely high-speed flight. (Lockheed)

Even Lockheed called it a "rigid rotor," although the term was technically incorrect.

Here the first Model 286 (N286L) demonstrator shows the retractable skid landing gear in the extended position. (Lockheed)



This is the Model 286 mockup. Note the differences between the mockup and the prototype (above), especially around the main rotor mast. Although intended for the civilian market, Lockheed also attempted to interest the military in the 286 design. (Lockheed)

The fifth Cheyenne (1005; 66-8830) was the Avionics Integration/Development Vehicle. It was the first aircraft equipped with the complete Integrated Helicopter Avionics System (IHAS). (Lockheed)



The extended landing gear ruins the sleek lines of the sixth Cheyenne (1006; 66-8831) in this February 1969 photo. Note the size of the 30-mm belly turret and the early-style sensor suite protruding from the forward fuselage under the swiveling gunner's station. (Lockheed)



Looking very much like the final product would have, the seventh Cheyenne (1007; 66-8832) shows its guns, TOW missile pods, and FFAR rocket pods. Note the later-style sensors under the gunner station. At the time of this February 1971 photo, all Army helicopters wore an overall olive-drab paint scheme with yellow caution and warning markings. (Lockheed)



*Cheyenne*



The third AH-56A (1003; 66-8828) photographed on 10 July 1968. Note the yellow tips on the main rotor blades, and the red and white stripes on the anti-torque rotor blades. This aircraft crashed off the California coast on 12 March 1969, killing test pilot Dave Beil. (Lockheed photo by Erik Miller)

The seventh Cheyenne (1007; 66-8832) fires 2.75-inch FFARs from pods on the out-board pylons. Note the bright orange caps on the TOW missile pods on the inboard pylons. All of the Cheyennes carried full-color national insignia. (Lockheed)



Three Cheyennes parked on the ramp at Oxnard, California. From the rear: #1002, #1003, and #1005. Note the open engine cowlings on the closest aircraft. (Lockheed)

# THE BEGINNING OF THE END

## THE LONG ROAD TO EXTINCTION

**T**he only Cheyenne flight test loss was recorded on 12 March 1969 when the third aircraft (1003; 66-8828) crashed off the coast near Carpinteria, California. Lockheed test pilot David Beil had been flying at approximately 2,500 feet altitude when the chase pilot noticed that the main rotor tip plane began to blossom rapidly. Soon the rotor was oscillating out of control, and the blades sliced into the canopy and tail boom. Beil was killed instantly.

All the Cheyennes were immediately grounded pending an investigation. By this time the fleet had accumulated 450 flight hours. It was not until October 1969 that the accident report was finally released; to say the least, it was controversial.

The report stated that prior to the fatal flight, the Cheyenne had never been flown at a rotor speed greater than 94 percent. This mystified the pilots that had flown the AH-56A, especially Don Segner, who remembers that the Cheyenne was routinely flown at 100 percent rotor speed from the earliest days. Lockheed responded that the aircraft was lost at approximately 230 mph true airspeed, but had previously flown as fast as 245 mph in level flight, and had reached 257 mph in a slight dive. Contrary to the Army's accusation, both the pilot and the aircraft had flown in this flight regime safely in the past.

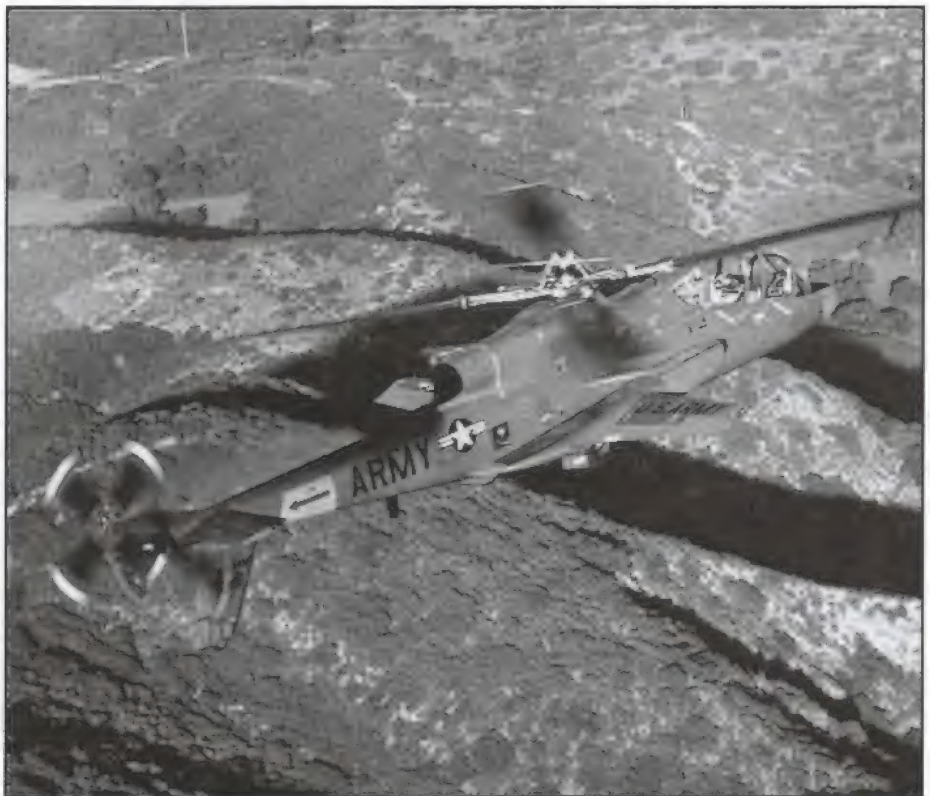
The Army stated that intentional 0.5P oscillations had been induced during the flight, despite warnings

against such action. The report concluded that "... LCC [Lockheed-California Company] failed in the exercise of due care and judgement in the planning and execution of flight 288 and, in doing so, failed to adhere to an acceptable level of sound industrial practice."

Don Segner remembers that while the 0.5P oscillation (usually known as a "half-P hop" phenomenon) was something to be careful of, it did not represent any significant danger in the hands of an experienced pilot. Various resonances are present in every helicopter rotor. These are characterized by the number of

times they peak per rotor revolution – a resonance that peaks once per revolution is written as "1P," etc. The half-P hop on the Cheyenne was a resonance that peaked once every two revolutions of the main rotor.

Continued investigation by Lockheed, the Army, the FAA, and the Stanford Research Institute began to uncover more details of the crash. The tests scheduled for that day called for Beil to pulse the controls at a given rate to excite the 0.5P oscillation and determine how far it would go before it became divergent. Previous testing had indicated that the risk of diver-



*The third aircraft (1003; 66-8828) in flight during December 1967. This is the aircraft that would crash and kill test pilot Dave Beil on 12 March 1969. (Lockheed)*

gence was very low, and flight test experience showed that any serious effects could be overcome by slowing down and allowing the oscillation to subside.<sup>1</sup>

The critical factor was for a pilot to recognize the onset of the resonance, and to stop moving the controls – which is not the normal reaction. Instead, Beil apparently became the victim of pilot induced oscillation (PIO). Various safety mechanisms<sup>2</sup> (locks) were installed on the collective to minimize potential PIOs, but Beil apparently had disengaged them, either to aid in the tests or due to personal preferences.<sup>3</sup> As the half-P hop increased in magnitude, Beil's arm acted as a mass that applied force to the collective during each oscillation. As in most PIOs, Beil was not aware his actions were compounding the problem. Subsequent simu-

lations showed that once the oscillation had been induced, it rapidly grew until the rotor system exceeded its  $\pm 3.5$ -g limit. In essence, the simulation showed that the dynamics of the seat and the pilot's left hand on the collective stick conspired to set up a classical resonance situation at the exact frequency of the half-P hop.

Changes made as a result of the accident investigation included stiffening the main rotor blades and control system, increasing the size and mass of the gyro, and changing the rotor geometry slightly to stabilize the dynamics. It also brought about a policy of doing envelope expansion tests from the front cockpit of the ninth aircraft (1009; 66-8834) where the swiveling gunner's seat was replaced by a downward-firing ejection seat from an F-104.<sup>4</sup>

## Political Turmoil

On 10 April 1969, an ongoing dispute between Lockheed and the Army over the progress of Cheyenne went public when a cure-notice, initiated by the Army contracting officer, Joseph A. Murray, and approved by General William B. Bunker, was sent to Lockheed. It said, in part: "You are hereby notified that you [Lockheed] have 15 days after receipt of this notice to satisfactorily demonstrate in writing your ability to cure your failure to make satisfactory progress toward the production and timely delivery of aircraft which will meet contractual requirements. Such demonstration should include specific plans to effect timely cures for the known technical problems."

At the same time, the Army publicly announced that the Cheyenne was seriously deficient in its performance. In particular the Army reported that the Cheyenne suffered from a critical unstable



*Don Segner poses with the ninth Cheyenne (1009; 66-8834). The Lockheed F-104 downward ejection seat is clearly visible in the front cockpit. Note the "warning" triangle on the side of the fuselage just below the boarding platform. (Don Segner Collection)*



*The weapons test vehicle (1006; 66-8831) maneuvers during tests at the Yuma Proving Grounds, Arizona. The aircraft is carrying the standard load of two triple-TOW missile launchers on the inboard pylons, and single 2.75-inch FFAR rocket pods on the outboard pylons. The nose turret has a 40-mm grenade launcher, and the 30-mm cannon is installed in the belly turret. (Lockheed)*

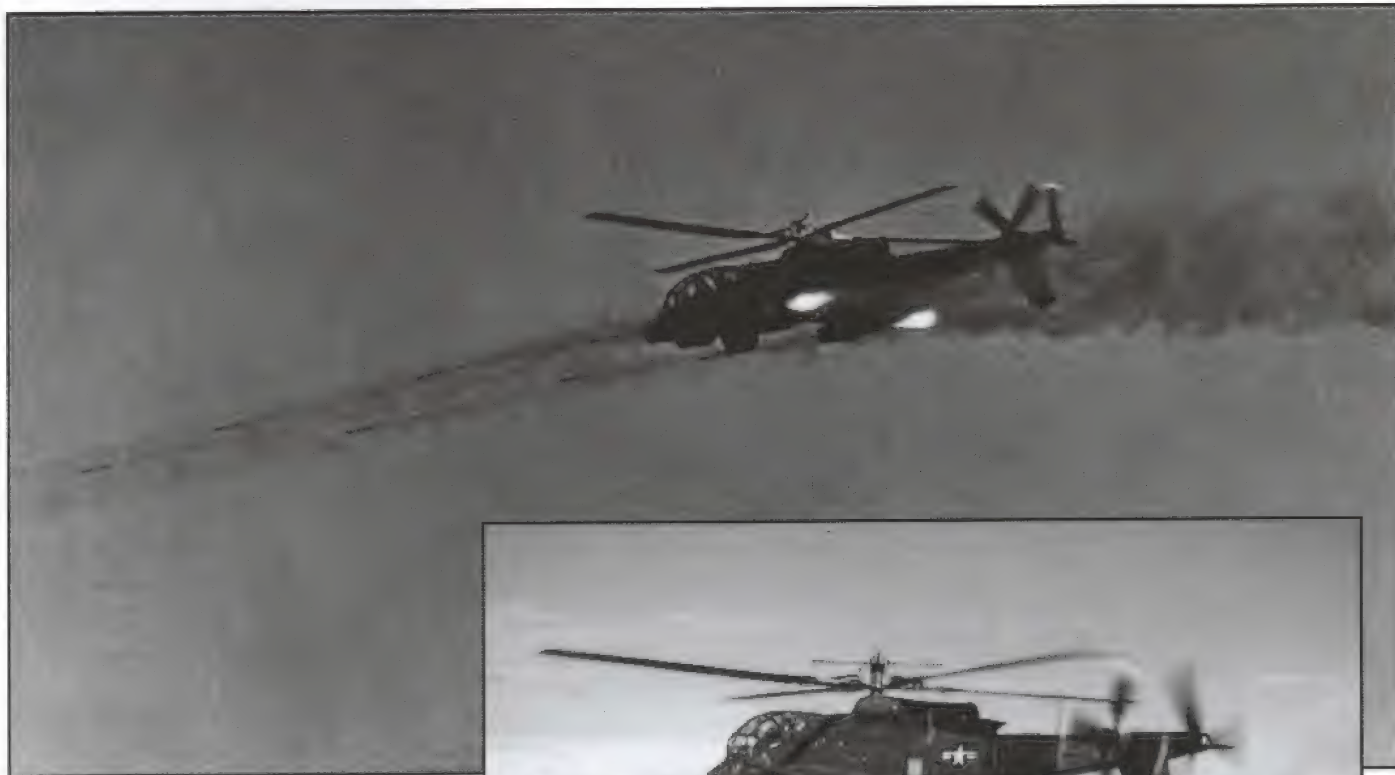
0.5P rotor oscillation throughout its operational flight envelope. This was seriously overstating the problem. Lockheed was well aware of this failing, and had already identified a potential cure. The oscillation was the result of the original control gyro having insufficient polar inertia to control the main rotor blades in pitch/roll under certain conditions. An improved control system (ICS) was already on the drawing boards that would, hopefully, correct the problem. In any case, the problem did not occur throughout the flight envelope, but only in small and well identified portions of it. As soon as a pilot identified the half-P hop, all he had to do was slow the aircraft down and the hop would eventually smooth itself out. It took awareness on the part of the pilot, and at times some skill, but the hop was not considered particularly dangerous if due care was exercised.<sup>5</sup>



The Army also cited 1P and 2P rotor instabilities at certain rotor mast bending moments and rotor RPM during autorotation landings. Don Segner cannot recall this ever occurring. Most people associated with the program also deny another Army claim – that excessive swashplate travel permitted the main rotor to impact the tail boom. The Cheyenne had suffered one tail

boom strike while on the ground which was attributed to excessive movement of the cyclic by an engineer during testing.

There were, however, some deficiencies quoted by the Army that were fact. The Cheyenne was somewhat overweight – a common problem in aircraft development. This reduced both performance



*Ship #1006 (66-8831) fires 2.75-inch rockets at the Yuma Proving Grounds. These are unguided rockets intended for use against troops and other soft targets. (Lockheed)*



and maneuverability, but Lockheed was working on some possible weight reduction efforts. There was excessive drag, which also reduced performance. Again, Lockheed and Army engineers had identified some fixes which would largely eliminate this concern in production aircraft. The transmission was proving to be less robust than expected, limiting the power that could be used. Again, engineers had already identified potential fixes for production aircraft. Perhaps the most disturbing problem was greater than expected 4P and 8P vibrations, normally associated with four-bladed main rotors, that were having a destabilizing effect on the gunner's sight. It was hoped that the new ICS flight control system would reduce these, but by

how much would not be known until flight testing was underway.

None of these problems were totally unexpected since the Cheyenne represented a quantum leap in helicopter technology and performance. A great deal of the problem rested with the original schedule estimates, which were hopelessly optimistic and did not allow time to fix problems. The attempt to accelerate the operational introduction of the Cheyenne from 1972 to 1970 only compounded the problem. It was becoming obvious that the first operational aircraft would not enter final assembly until December 1969 at the earliest.<sup>6</sup>

On 19 May 1969, the Army cancelled Cheyenne production due to

of nonperformance on the part of Lockheed. Portions of the first fuselage were already in the assembly jigs in Burbank. By claiming Lockheed had defaulted on the terms of the contract, the Army expected Lockheed to return the \$54 million that had been allocated for long-lead production items. Interestingly, although the production contract was cancelled, the Army went out of its way to emphasize that the development contract remained in force and that they were anxious for development to continue. The Army continued to fund the development effort with \$17 million in FY70 and FY71 funds.

By this time, Lockheed was a beaten company. The crisis surrounding the development of the C-5 Galaxy

and the AH-56 Cheyenne had taken a serious toll on the company's finances. Over \$1,000 million in claims and counter-claims were pending with the U.S. government, all centered around the now-abandoned TPP concept. In fact, by 1974 Lockheed would be so close to bankruptcy that the government would have to guarantee loans to the company to keep it from closing its doors.

### Yet More Testing

But the promise of the Cheyenne was too great for the Army to completely abandon it. By the end of 1969 the Army began to express its satisfaction at the progress Lockheed was making towards overcoming development problems. Three of the original ten aircraft were being used in a new test effort aimed at confirming various modifications had indeed fixed the previously identified problems. Another AH-56 (1008; 66-8833) was being used as a non-flying avionics testbed.

One of the results of the accident investigation was a recommendation to test a full-size AH-56A in the 40x80-foot wind tunnel at the NASA Ames Research Center in Mountain View, California. Despite the misgivings of some Lockheed and Army engineers, the tests were scheduled for September 1969. Besides dynamic investigations, it was expected that information on fuselage drag (which was higher than expected) and forward flight performance on the main rotor, anti-torque rotor, and propeller could be obtained. Following the successful completion of cold weather and anti-icing tests in Canada, the landing gear attachment points on the last aircraft (1010; 66-8835) were modified to allow mounting to a three-strut pedestal in the wind-tunnel. For safety reasons, fuel was supplied from an external tank outside the wind-tunnel itself. Electrically-operated actuators were installed in the control system that would allow two test pilots to "fly" the aircraft

from the control room. One pilot would control pitch, another would control roll. Both were given displays that showed rotor-shaft bending in pitch and roll so that they could determine the appropriate control inputs. The wind-tunnel measurement system provided information on the total lift and drag so that the pilots could put the aircraft into a "trimmed flight" condition. Initial tests were made without the main rotor installed, mainly to verify the procedures to be used, and to document any resonances in the support struts that might be excited by operational rotor speeds.<sup>7</sup>

Following the initial checkout, the blades were installed and expansion of the test envelope began on 17 September 1969. At approximately 100 knots, as the rotor thrust was being increased to 20,000 pounds, the main rotor began to flap, indicating that the stabilizing blade-bending feedback to the gyro was being overpowered



*With some misgivings, Lockheed agreed to an Army request to test the tenth Cheyenne (1010; 66-8835) in the NASA Ames Research Center 40x80-foot wind tunnel. The aircraft is seen here on 17 September 1969 just prior to the beginning of testing. The aircraft was mounted via attachments to its landing gear fittings. (NASA photo by Lee Jones)*



*Lockheed's misgivings proved accurate – an accident resulted in the destruction of Ship #1010 in the 40x80 tunnel later on 17 September 1969. The same blade pitching moments and tip-deflection effects that accounted for the pitch-up tendency in high-speed flight had manifested themselves in the wind-tunnel at only 100 knots. (NASA photo by Lee Jones)*



*There had been at least one other rotor strike during the program. On 21 November 1968 the main rotor on Ship #1005 (66-8830) struck the rear canopy during ground tests when an engineer allowed a rotor oscillation to get out of hand. It is unlikely that such a strike could have occurred in flight for many of the same reasons the accident in the Ames wind tunnel could not have happened in flight – if the aircraft had been airborne, the entire aircraft would have oscillated, avoiding the strike. This could not happen with the aircraft firmly planted on its landing gear. Note the broken plexiglass just above the front of the sponson. (San Diego Aerospace Museum Collection)*

by other effects. The movement became severe enough that the main rotor sliced into the tail boom, severing the aircraft in half. With its mounting system compromised, the aircraft broke up and the entire fuselage disappeared down the wind tunnel. One of the 20-pound tip weights from the main rotor was sheared off and penetrated the upper part of the wind-tunnel control room, fortunately not injuring anybody inside. The remains of the Cheyenne were found upside down at the first set of tunnel turning vanes; the wind-tunnel was damaged, and the Cheyenne destroyed.

Subsequent analysis of the accident showed that the same blade pitching moments and tip deflection effects that accounted for the pitch-up tendency in high-speed flight had manifested themselves in the wind-tunnel at only 100 knots. The phenomenon was more pronounced in the wind-tunnel since the fuselage was held firmly on its mounting struts and could not flex with the rotor moments as it would in flight. The situation was compounded by the fact that the pilot lacked sensory cues to the impending problem; something that would have been available to a pilot in the cockpit. The blade

pitching moments were later identified as being primary nose-down airfoil section moments caused by retreating blade stall.

The final analysis showed that the accident in the Ames wind tunnel could not have happened in flight. It also showed that the half-P hop that had killed Beil could not be duplicated in the wind tunnel since the fixed supports would prevent the plunge motion that was the key to the accident.<sup>8</sup>

The need to understand the complex dynamics of the main rotor and gyro had already prompted

the development of a sophisticated computer program that could predict the in-flight forces on the blades and their deflections under load. The program, named REXOR, was used for several years by military and NASA engineers to investigate the rotor dynamics of new designs. The program also contributed to the tweaking of the ICS and the development of the AMCS.<sup>9</sup>

By 23 October 1970, the Cheyenne had accumulated 1,578 flights

totaling 801.4 flight hours. Plans for FAA certification were abandoned and the goal now was simply to meet contractual requirements.

The sixth aircraft (1006; 66-8831) was performing weapons testing at the Yuma Proving Grounds in Arizona. All of the weapons had been test fired on the ground before proceeding to aerial demonstrations, including TOW missiles, which were fired into a large box while the aircraft was parked. In the air, the

Cheyenne was particularly impressive during weapons tests. It was not uncommon for the pilot and gunner to engage separate targets on either side of the aircraft with pinpoint precision, then quickly switch to a direct frontal attack using the FFAR rockets. In one test, the aircraft launched TOW missiles at two targets – one on either side of the aircraft – in quick succession, hitting both of them.

Modifications to the collective boost system and the pitch arm that connected the gyro to the main rotor finally eliminated the half-P hop. Shaving a small amount of metal from the leading and trailing edge of the rotor hub largely

*From the beginning, the ninth aircraft was meant to be flown from the front cockpit that was fitted with the F-104 ejection seat. Note the full flight instrumentation on the front panel, and the conventional cyclic control stick. (San Diego Aerospace Museum Collection)*



*The ninth aircraft (1009; 66-8834) under construction at Van Nuys. This aircraft replaced Ship #1003 as the envelope expansion vehicle, and was also equipped with a stronger transmission and higher-power engine. (San Diego Aerospace Museum Collection)*



*Sometimes, things went wrong. Ship #1007 (66-8832) was forced to land at Yuma due to mechanical problems on 22 April 1970. No damage was done, and the aircraft resumed flying later in the week. (Lockheed)*

eliminated the 4P and 8P vibrations. Another problem had been the inability to maintain steady left sideward flight under 30 knots. It was found that the wake from the main rotor was impinging upon the anti-torque rotor. Analysis showed that the anti-torque rotor should rotate such that the blade closest to the main rotor was going upward, so the rotation of the anti-torque rotor was reversed, curing the problem.<sup>10</sup>

The ninth aircraft received all of these changes, along with a strengthened transmission and drive system. This allowed the T64-GE-16 to operate at 3,925 shp, instead of the derated 3,435 shp that had been used thus far in the test program. This aircraft also received a revised rear canopy that used outward-opening access panels instead of the sliding panel used previously, finally solving the

annoying vibration that had been experienced since the beginning of the program.

By late 1970, the test program was advancing to most everybody's satisfaction. The Army again released funds for the development of the TOW guidance system and the night sighting system. Since the war in Southeast Asia was winding down, the Army began to consider fully developing the anti-armor capability of the Cheyenne in view of its probable role in Europe.

#### **APE I**

The Army Preliminary Evaluation (APE) I and a portion of the research and Development Acceptance Test I were conducted on the AH-56A by the Army Aviation System Test Activity at Yuma Proving Grounds between 30 January and 23 December 1971. These tests

were intended to gather stability and control data for determining the airworthiness of the AH-56A and to examine the corrective action taken to eliminate previously noted deficiencies.

The tests uncovered 5 deficiencies and 51 shortcomings. The deficiencies included: (1) unacceptable static lateral-directional stability characteristics which preclude adequate aircraft control, (2) uncommanded aircraft motion and loss of control during maneuvering flight, (3) excessive vibration levels, (4) excessive rotor speed decay following simulated engine failures at high airspeeds, and (5) inadequate directional control margins in sideward flight. None of the rotor dynamic instabilities previously encountered were noted during these tests, indicating the ICS had solved some problems. The Army noted that the "... capability of the

pusher propeller to provide rapid deceleration and to control air-speed independently of dive angle is an excellent feature."<sup>11</sup>

The sixth (1006; 66-8831) and ninth (1009; 66-8834) aircraft were used for the APE I tests. Both had been equipped with the ICS and reversed anti-torque rotor prior to the test beginning, and the ninth aircraft had been fitted with a downward-firing F-104 ejection seat.

Following the APE I tests, the ninth aircraft was again upgraded, this time with a more powerful 4,275 shp T64-GE-716 engine and a production-standard ICS control system. With these changes the aircraft exceeded its performance requirements, but pilots were still not totally happy with its control response or stability under some conditions.

Long before the two accidents, Lockheed had begun studying methods to solve the unstable gyro-feedback problem. This resulted in the gyro being moved from the top of the rotor to below the transmission and also being made considerably smaller and lighter, consequently turning much faster. This modified system was known as the advanced mechanical control system (AMCS), and replaced the improved control system (ICS) as the baseline design. At the same time, an advanced electronic control system (AECS) was also designed as a fallback in case the AMCS did not work.<sup>12</sup>

The primary differences between the AMCS and ICS were in the method for converting primary gyro precession into main rotor cyclic pitch change, and the meth-

ods of feeding back blade flapping signals to the gyro. In both control systems, the pilot cyclic control movement was transmitted mechanically to hydraulic servos which applied force, through springs, to the control gyro, causing it to precess. In the ICS, the gyro was connected directly to pitch arms on the main rotor blades, therefore, gyro precession was transmitted mechanically to the rotor blades, causing pitch changes. The feedback to the gyro was through these same mechanical links, which allowed feedback from blade flap, pitch, lead-lag, and other sources. The flapping feedback is desirable, but the other inputs caused handling qualities and rotor stability problems. The AMCS was designed to alleviate those problems by transmitting the gyro precession to irreversible



*The entire test crew in front of Ship #1009 (66-8834) prior to beginning of APE I tests on 31 January 1971. (Lockheed via the Don Segner Collection)*

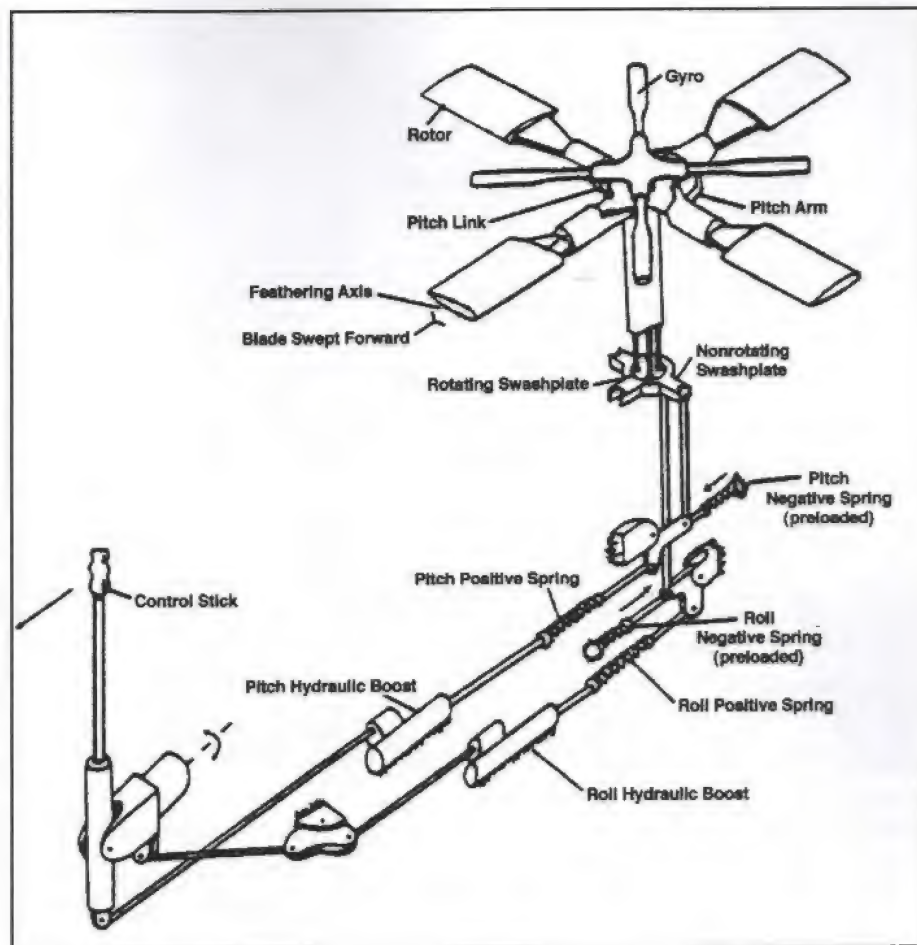
hydraulic servos. These servos caused an angular displacement of the sliding spatial lever which, in turn, resulted in cyclic blade pitch changes. The irreversible servos eliminated all feedback from the rotor to the gyro through the pitch change linkage. A separate system was incorporated to provide flapping feedback to the gyro.<sup>13</sup>

The development of AMCS would, however, require an additional 15 months of testing, including a return to the whirl rig in Rye Canyon. Afterwards, the Army approved installing the system into the seventh aircraft (1007; 66-8832). During 61 hours of performance testing in late 1972, Don Segner successfully revalidated the entire flight envelope, and it appeared the Cheyenne's design problems were finally behind it.

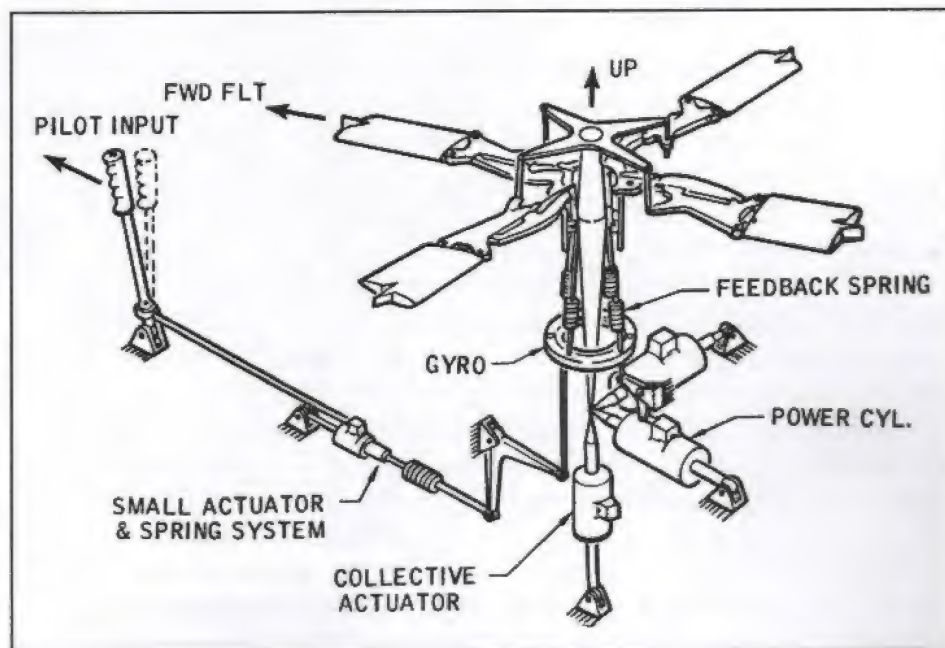
## The End

It may have seemed that the Cheyenne had experienced too many problems, but in the words of Johnny York, the Director of Defense Research and Engineering:

*The Advanced Mechanical Control System (AMCS) was the key to solving the last of the Cheyenne's controllability deficiencies. The AMCS moved the gyro from the top of the rotor mast to under the transmission, and is easily identifiable in photos because of this. Only the seventh aircraft (1007; 88-6632) was retrofitted with the new system. Don Segner flew 61 hours of evaluations with the new system during late 1972 and demonstrated that the AMCS had cured all the previous difficulties with Cheyenne. But it was too late to save the program.*  
(Don Segner Collection)



*This was the control system used in the Cheyenne until the advent of the AMCS shown below. Note that the gyro is on top of the main rotor and is connected directly to the pitch arms on the main rotor blades. This allowed some undesirable feedback to be transmitted to the gyro, causing some handling quality and rotor stability problems. (Don Segner Collection)*





*The ninth Cheyenne (1009; 66-8834) during testing of the improved control system (ICS) at Yuma Proving Grounds in 1971. Note the large white target in the background. Judging by the blurred background, Don Segner and the Cheyenne were moving very rapidly when this photo was taken. (Lockheed via the Don Segner Collection)*

"I think it was an aircraft with normal complications in development, certainly not out of range of reasonable concern for one that was pushing the envelope. ... I don't think we have had any bigger revolution in helicopters."<sup>14</sup>

The Army was also beginning to acknowledge that it had undertaken a program whose technological demands were beyond its managerial abilities. The TPP contract did not help anything. Jack Real, Lockheed's first Cheyenne program manager recalls: "The Army had never bought helicopters on its own."<sup>15</sup> ... This was the first time they were going to develop and procure a helicopter for themselves. They were like kids in a candy shop." Real also recalls that the Army "insisted on extremely demanding requirements." In many cases, such as the five-axis autopilot and terrain-fol-

lowing radar, this forced Lockheed to invent an entirely new technology. But if the Army was at fault for insisting on unrealistic requirements, Lockheed was equally as at fault for promising it could deliver them. Explains Johnny Foster, "If Lockheed hadn't promised they could do all of that, they wouldn't have gotten the contract, and if the Army hadn't demanded all that and believed Lockheed, it wouldn't have awarded the contract."<sup>16</sup>

Although the Cheyenne appeared to have solved its performance and control problems, the time it had taken had introduced other concerns. The weapons system, which had been state-of-the-art when the AH-56A had been designed, was already showing its age. By the early 1970s, digital systems were being developed that were lighter, faster, and more accurate than the

largely analog and mechanical systems in the Cheyenne. In particular, the Doppler attitude/heading reference system did not work particularly well, and the Army had no confidence it ever would.

During early 1972, the sixth aircraft conducted weapons tests at Hunter-Liggett AAF and Yuma, and the Cheyenne was proving to be a very good weapons platform. The first shot from the 30-mm cannon could consistently hit a 10-inch bulls-eye from a range of almost two miles. A typical test of the combined automatic navigation and fire control system consisted of peeking over a hill, acquiring the target in the gunner's sight, dropping back behind the hill, flying up the valley three miles or so, then popping up again with the sight still dead on the target – all without the gunner having touched a thing.<sup>17</sup>

With the dynamic problems solved and most other systems working well, Lockheed and the Army were ready to reinstate the production contract. But it was not that simple. The Air Force was in the middle of the A-X close air support development program, and the A-X and AAFSS looked very similar in capabilities. Congress questioned the need for both programs. In addition, Lockheed's projected unit cost had increased to over \$3 million.<sup>18</sup>

In an effort to sell the Cheyenne to the Senate Armed Services Committee, the Army arranged a fire-power demonstration at the Yuma Proving Grounds. The Cheyenne had fired 130 TOW missiles without a single failure, a significant achievement given that the TOW itself was experiencing about a 10 percent failure rate in overall testing. But on this day, in full view of the attending Senators, the first TOW launched by the AH-56A flew straight into the ground. A second TOW successfully

hit the target, but the damage was done. Although the Army and Lockheed tried to explain that the failure was one of the missile, not the AH-56A, and that both were still in development, it was to no avail.

On 9 August 1972, the Army cancelled the Cheyenne program in its entirety, after an expenditure of over \$400 million. The estimated unit cost had climbed to over \$4 million, and would undoubtedly top \$5 million when new avionics were added. The lack of a true night and all-weather capability was cited as one of the reasons for cancellation. The Army also believed the aircraft was too large and presented too tempting a target for a new generation of shoulder-fired surface-to-air missiles.

Although the program had been cancelled, the Army conducted an engineering evaluation of the seventh aircraft equipped with the AMCS between 19 February and 14

March 1973 at Yuma Proving Grounds. The testing consisted of 20 flights totaling 18.2 hours. The Army found that the AMCS corrected most of the remaining problems with the Cheyenne control system, and also reduced pilot workload and increased overall stability. One deficiency was still noted, however, and that was the inability to perform low-speed low-level missions below 120 knots due to lateral-directional instabilities.<sup>19</sup>

At the completion of the evaluation, the Cheyenne had flown to 215 knots in level flight and 245 knots in a dive. High-speed maneuvers had included pull-ups to +2.6-g and push-overs to -0.2-g. High control power, quick response times, and low cross-coupling provided the aircraft with excellent handling qualities. Pitch-up tendencies and rotor blade contamination of control characteristics had been eliminated. The desirable features of the hingeless rotor,



*Ship #1006 (66-8831) at Edwards AFB undergoing laser rangefinder calibration during August 1968. (Lockheed)*



*Ship #1006 (66-8831) was painted in the Army's tactical camouflage late in its test program. The new paint made the aircraft look a great deal more sinister. This photo was taken over Yuma on 21 March 1972. (Lockheed)*

namely a wide center-of-gravity range, control capability at low load factors, and low tip excursions during maneuvers had been preserved with the AMCS.<sup>20</sup> The aircraft was even demonstrated in a continuous 720° turn at 2-g – something no other helicopter had ever done.<sup>21</sup>

The flight program ended on an unhappy note. While returning from what would be the Cheyenne's last test flight (in 1007: 66-8832), Segner decided he would overfly his house just north of the Ontario airport on the way home. The weather was getting bad up against the mountains, suggesting it was time to return to the flight test location. Then a "chip light" came on, and Segner made a precautionary landing at Ontario. The Army denied Lockheed's request to fly the aircraft back to the test location, and it was unceremoniously placed on a truck and taken back to Burbank.

Almost immediately after the

Cheyenne was cancelled, the Army announced a design competition for the Advanced Attack Helicopter (AAH). This competition requested a very different helicopter. Based on the experience from Southeast Asia, the Army decided that high speed was not all that important, so the new attack helicopter would only need to fly at 145 knots. This also avoided many of the Air Force objections to the Cheyenne. Based on combat analysis, the Army also adopted a philosophy that two engines were better from a survivability perspective.

Lockheed tried to interest the Army in the CL-1700 twin-engine version of Cheyenne without the pusher propeller, but to no avail. Instead the Army awarded preliminary development contracts to Bell for the YAH-63 and Hughes for the YAH-64, a competition that was ultimately won by the Hughes (later McDonnell Douglas, still later Boeing) AH-64 Apache.

Don Segner summed it up succinctly, "What killed it? No one thing. The excuse given was roles and missions. It died because of the changing political rules, the Army's naiveté, the McNamara total package procurement approach, interference from within the Army from people that did not know what they were doing, and people in industry who did not want us to succeed."<sup>22</sup>

Although the American Helicopter Society seemed to make a point of not recognizing the contributions of Lockheed and the Cheyenne test team, other organizations were more forthcoming. In 1972 Don Segner was awarded the Iven Kinchloe Memorial Award, given annually by the Society of Experimental Test Pilots (SETP) to the outstanding test pilot; and also the Chanute Award, given annually by the American Institute of Aeronautics and Astronautics (AIAA) for outstanding achievement in the field of aeronautical engineering and piloting.

<sup>1</sup> Hewson, Robert, *Beyond the Frontiers: Lockheed AH-56 Cheyenne – The Lost Tribe*, *Wings of Fame*, Vol. 14, AIRtime Publishing Inc., 1999, 154-155. <sup>2</sup> Included a manual friction lock to eliminate "collective bounce," a manual lock for the collective, and an electric lock that kept the collective down during forward flight. <sup>3</sup> Many pilots find collective locks annoying and disable them if possible. <sup>4</sup> Prouty, Ray W. and Yackle, Al R., *The Lockheed AH-56 Cheyenne – Lessons Learned*, AIAA Document 92-4278, presented at the AIAA Aircraft Design Systems Meeting, 24-26 August 1992, Hilton Head, S.C., p. 8. <sup>5</sup> Hewson, Robert, *Beyond the Frontiers: Lockheed AH-56 Cheyenne – The Lost Tribe*, *Wings of Fame*, Vol. 14, AIRtime Publishing Inc., 1999, p. 152. <sup>6</sup> Prouty, Ray W. and Yackle, Al R., *The Lockheed AH-56 Cheyenne – Lessons Learned*, AIAA Document 92-4278, presented at the AIAA Aircraft Design Systems Meeting, 24-26 August 1992, Hilton Head, S.C., p. 8. <sup>7</sup> Ibid. <sup>8</sup> Ibid. <sup>9</sup> Ibid. <sup>10</sup> Ibid, p. 7. About the same time, a similar change was introduced on the Bell UH-1 and AH-1, and the Russian Mil Hind. No scientific explanation was ever found for the phenomenon. <sup>11</sup> Army Preliminary Evaluation I and Research and Development Acceptance Test I on the AH-56A Cheyenne Compound Helicopter, Final Report, March 1972, p. (abstract). <sup>12</sup> Prouty, Ray W. and Yackle, Al R., *The Lockheed AH-56 Cheyenne – Lessons Learned*, AIAA Document 92-4278, presented at the AIAA Aircraft Design Systems Meeting, 24-26 August 1992, Hilton Head, S.C., p. 8. <sup>13</sup> Engineering Evaluation of the AH-56A Compound Helicopter with the Advanced Mechanical Control System, U.S. Army Aviation Systems Test Activity, Edwards AFB, California, March 1973, p. 1-2. <sup>14</sup> Foreman, Brenda Dr., *What Killed the Cheyenne*, *VertiFlight*, Vol. 42 No. 3, May/June 1996, p. 23. <sup>15</sup> During the 1950s and most of the 1960s, the Army conducted helicopter research at Fort Eustis, and wrote requirements, but the Air Force procured the aircraft through its offices at Wright Field. This was part of the original agreements reached when the Air Force had been made a separate service in 1947. This same agreement allowed the Army to operate aircraft weighing less than 6,000 pounds (empty) and helicopters less than 20,000 pounds (empty). See Yackle, Al, *Cheyenne – Killed in Roles and Missions Battle*, *VertiFlight*, Fall/Winter 1998, Vol. 44 No. 4, p. 29. <sup>16</sup> Foreman, Brenda Dr., *What Killed the Cheyenne*, *VertiFlight*, Vol. 42 No. 3, May/June 1996, pp. 25-26. <sup>17</sup> Prouty, Ray W. and Yackle, Al R., *The Lockheed AH-56 Cheyenne – Lessons Learned*, AIAA Document 92-4278, presented at the AIAA Aircraft Design Systems Meeting, 24-26 August 1992, Hilton Head, S.C., p. 9. <sup>18</sup> Ibid. <sup>19</sup> Engineering Evaluation of the AH-56A Compound Helicopter with the Advanced Mechanical Control System, U.S. Army Aviation Systems Test Activity, Edwards AFB, California, March 1973. <sup>20</sup> Prouty, Ray W. and Yackle, Al R., *The Lockheed AH-56 Cheyenne – Lessons Learned*, AIAA Document 92-4278, presented at the AIAA Aircraft Design Systems Meeting, 24-26 August 1992, Hilton Head, S.C., p. 8. <sup>21</sup> Hewson, Robert, *Beyond the Frontiers: Lockheed AH-56 Cheyenne – The Lost Tribe*, *Wings of Fame*, Vol. 14, AIRtime Publishing Inc., 1999, p. 157. <sup>22</sup> Foreman, Brenda Dr., *What Killed the Cheyenne*, *VertiFlight*, Vol. 42 No. 3, May/June 1996, p. 27.

Don Segner flies  
Ship #1007  
(66-8832) with the  
Advanced  
Mechanical Control  
System (AMCS) on  
test flight over Yuma  
Proving Grounds in  
February 1973. Note  
the lack of a gyro  
over the main rotor.  
(Don Segner  
Collection)



Ship #1007 during  
first flight with the  
AMCS in February  
1973. (Don Segner  
Collection)



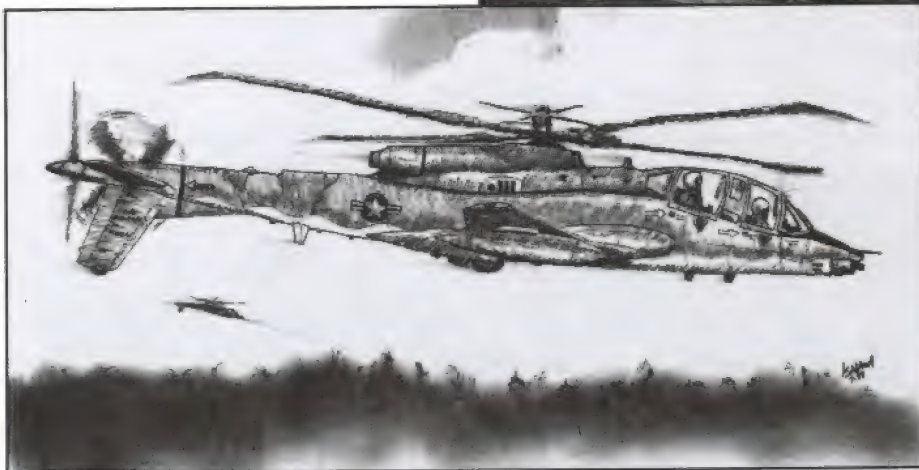
During the course of Cheyenne's development, Lockheed proposed adapting the AH-56A for uses other than the AAFSS role. A proposed Navy version had a rescue hoist in a compartment behind the pilot that could be used to winch up downed pilots in combat zones. (Lockheed)



A twin-engine rescue version could also be fitted with air-to-air refueling capabilities, allowing it to undertake long-range search-and-rescue missions. (Lockheed)



A Marine version was proposed in 1966. It differed little from the Army version, although the Marines later expressed a decided preference for twin-engined attack helicopters (look at the AH-1J, etc.). Lockheed could have adapted the basic Cheyenne to use a twin-pack engine. (Don Segner Collection)



Reproduction of artwork done for Joint Chiefs of Staff (JSC) briefing on Air Force Cheyenne proposal. (Artwork by Marty Isham)

# THE SCIENCE

## TECHNICAL DESCRIPTION OF THE AH-56A

**T**he Cheyenne was slightly schizophrenic – it was not really sure if it was an airplane or a helicopter. The flight manual for the sixth aircraft (1006; 66-8831), from which most of the material in this section is taken, contained some interesting descriptions of the AH-56A's operation.

"The compound helicopter with a rigid rotor possesses maneuvering characteristics far above conventional helicopters, but allowances must be made in judging distances when operating at high speed close to the ground. Flight control and stability will remain good even at zero g's."

"The compound helicopter is not limited to one climb condition; collective and beta controls can be varied to suit the needs. For maximum performance one control should be set and the other control used to achieve desired power. If vibration increases at the desired climb speed, the collective control should be lowered slightly to reduce it."

"Transition from hover to forward flight is accomplished easily in the normal manner or by using the pusher propeller. ... During transition there is an increase in vibration and a momentary right roll that is easily controlled; care must be exercised not to over-control at this point."

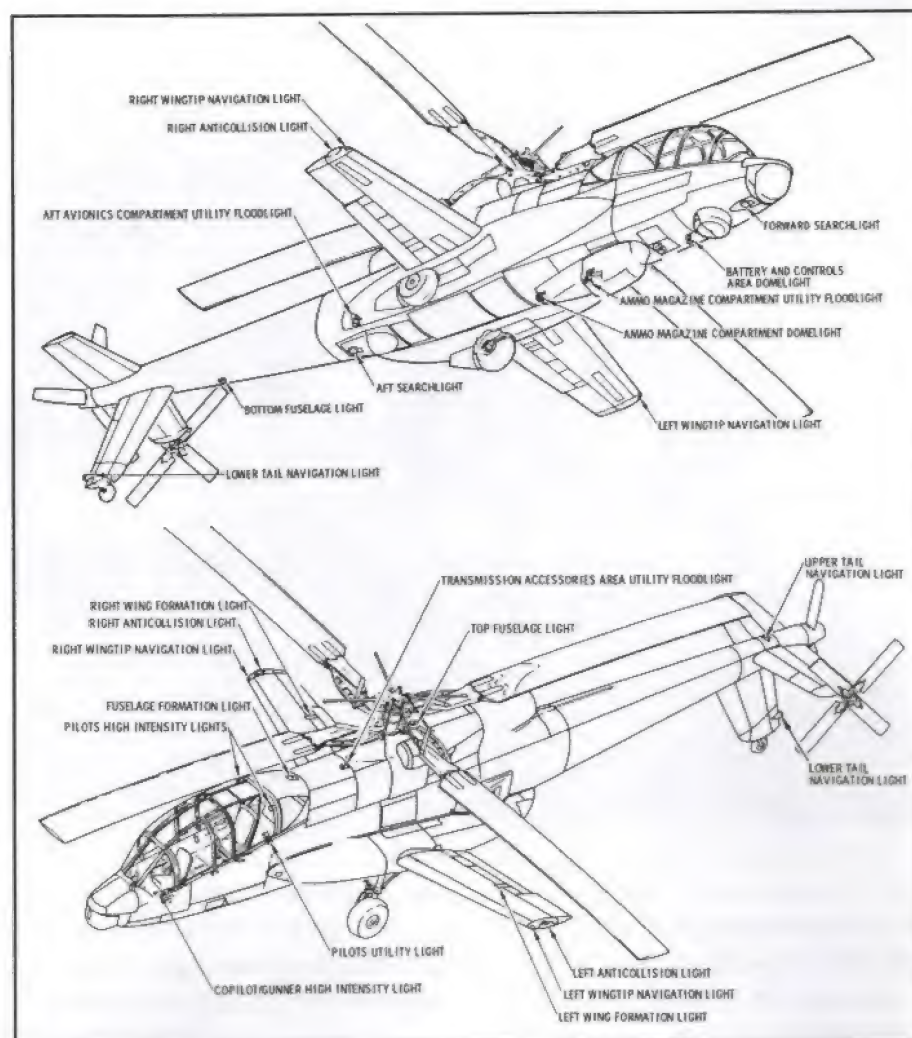
*Major highlights of the Cheyenne before the AMCS was added.*  
(U.S. Army)

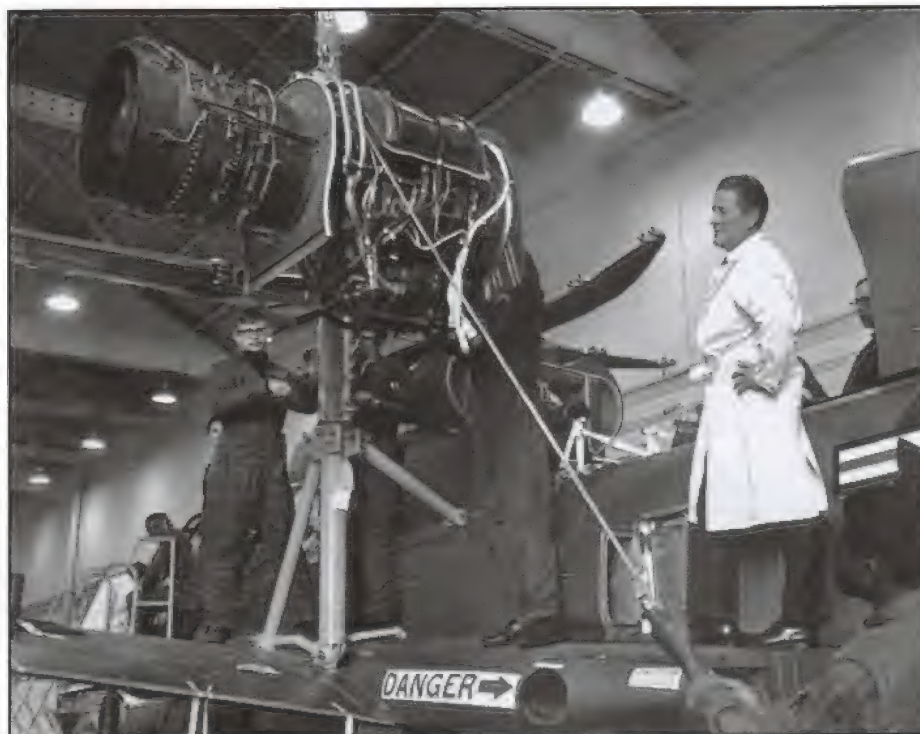
"Descents can be accomplished in many ways and the pusher propeller is very effective in maintaining air-speed even during steep dives."

### Engine<sup>1</sup>

Power was supplied by a single General Electric T64-GE-16<sup>2</sup> turboshaft engine. Initially this engine was derated to 3,425 shp, but improvements to the rotor and gearbox allowed some aircraft to use the original rating of 3,925 shp. The ninth aircraft received an

improved 4,275 shp T64-GE-716 turboshaft engine late in its test program. Both engines were substantially similar; the basic engine components included a 14-stage compressor, combustion chamber, two-stage gas generator turbine, and a two-stage free power turbine. The outer shaft of the coaxial power-shaft coupled the gas generator to the engine compressor and the accessory gearbox; the inner shaft coupled the power turbine to the main transmission. The engine weighed 700 pounds.





*Army maintenance training on Ship #1008 (66-8831) during May 1968. Note how the engine can be removed using a small lift that bolts onto hardpoints on the aircraft itself. (Lockheed)*



*The General Electric T64-GE-16 engine and transmission as installed on the first Cheyenne (1001; 66-8826) on 7 May 1967. With the cowling removed, mechanics could work on most components while standing on the large walkway on top of the sponson, eliminating many of the usual maintenance stands. (Lockheed)*

## Air Intakes

The designers of the Cheyenne had thought about possible operating conditions the helicopter might encounter. Because of this, two alternate sources of engine intake air were provided. The primary air intakes were located beside the main rotor mast; alternate filter cowls were located flush with the sides of the engine compartment along each side of the fuselage. The pilot selected which set of intakes to use based on conditions. If operating near the ground in a dusty area (or in a dust storm at any altitude, etc.), the pilot would place the engine air source switch in the FILTER position, which would close flaps inside the primary air intakes and force the engine to suck air through the filters. The filters were a series of small perforated plastic tubes; one end of each tube had a swirl vane molded into it that caused the in-rushing air to spin. Centrifugal force then caused the dirt and foreign matter to collect in a cavity at the base of the tubes where a scavenge fan purged the debris and blew it overboard. Available power was reduced slightly using the filtered intakes.

## Main Rotor

The four-bladed main rotor provided lift and cyclic control of the aircraft. Torque for rotating the main rotor was obtained from the transmission through the main rotor mast. With the engine power turbine set at 100 percent (13,600 RPM) the main rotor rotated at 246 RPM in the traditional<sup>3</sup> counter-clockwise direction (right blade forward; left blade aft). Collective and cyclic pitch of the main rotor blades was controlled by a gyro in the flight control system.

The main rotor consisted of a fixed hub, four movable hubs, four tension-torsion packs, four blades, and four pitch arms. Each of the blades was bolted directly to a movable hub that was attached to the fixed hub via two self-lubricating bearings and a tension-torsion pack. All centrifugal blade loads were carried by the tension-torsion packs. The pitch angle of the blades was controlled to the pitch arms which were rigidly fastened to the top of movable hubs. Pitch links connected the pitch arms to the control gyro in the flight control system. Each blade had adjustable balance weights located inside the blade tip.

### Propeller

The Hamilton-Standard three-bladed propeller at the rear of the aft fuselage generated thrust along the longitudinal axis of the aircraft. This permitted high speed forward flight and limited rearward flight. The propeller also provided thrust for ground taxiing and could act as a speed brake or thrust reverser in flight. A drive shaft from the main transmission drove a gearbox in the aft fuselage. The propeller was driven via a straight-through drive from the gearbox, while the anti-torque rotor was driven via a right-angle drive from the same gearbox. With engine power at 100 percent (13,600 RPM), the propeller rotated at 1,717 RPM. The direction of rotation was counterclockwise, viewed from the aft of the aircraft.

The propeller gearbox and hub were an integral assembly. A hydro-mechanical actuator was installed along the centerline of the gearbox and hub to control blade pitch (beta angle). The propeller blades were constructed of fiberglass epoxy-laminated covers bonded to

tubular steel spars. The inner voids were filled with low-density foam.

Propeller pitch (beta angle) was controlled by a propeller twist grip located on the forward end of the collective lever in each crew station. This was one of the controls unique to the Cheyenne. The grip was labeled THRUST with FWD and AFT arrows showing the direction of rotation for increasing thrust (rotating the grip outboard increased forward thrust). The beta angle could be varied between -17.2° and +40.8°. If the hydraulic control system was damaged or inoperative, counterweights acting in conjunction with aerodynamic and centrifugal forces would feather the blades.

The propeller was fitted with a negative torque relief (delta-beta) system that automatically removed propeller power demand from the main transmission in the event of an engine failure, thus reducing main rotor RPM loss during autorotation. This "negative torque compensator" drove the beta angle to 8°.

### Anti-Torque Rotor

The four-blade anti-torque rotor was mounted on the outboard end of the left horizontal stabilizer. This rotor provided direction control of the aircraft and also compensated for the torque produced by the main rotor. Torque for rotating the anti-torque rotor was obtained from the main transmission through a drive shaft that also drove the pusher propeller. With engine power at 100 percent (13,600 RPM), the anti-torque rotor spun at 1,238 RPM. The direction of rotation was reversed during the flight test program to be clockwise (top blade aft; bottom blade forward).

The anti-torque rotor consisted of a spindle, collective control, input yoke, hub, and four blades. The spindle connected the hub to the drive shaft and supported the collective control, which consisted of rotating and non-rotating sections. Pitch links connected the rotating section to pitch arms attached to the roots of the blades. Both sections moved as a unit along the spindle to change the collective pitch of the blades. Four spindles and sleeve assemblies in the hub provided for pitch change (feathering) movements and blade attachment. The four constant chord blades were constructed of aluminum honeycomb bonded to a titanium sheet metal spar and covered with titanium. The leading and trailing edge cavities were filled with plastic foam.

### Fuel System

Three internal fuel tanks were provided; a 300-gallon tank in the mid-fuselage, a 78-gallon tank in the left sponson, and a 60-gallon tank in the right sponson. All but the top surfaces of the internal tanks were self-sealing. The Cheyenne could carry five external fuel tanks, a 450-gallon one on each wing hard point, plus a 300-gallon tank on one sponson station (it could be carried on either station, but not both). The external fuel tanks were not self-sealing, but could be jettisoned in flight. Each fuel tank had an individual filler for gravity-fueling, or a single-point refueling system was installed with the connector in the aft portion of the right sponson.

### Electrical and Hydraulic Systems

Aircraft electrical power was provided by two engine-driven 22 KVA AC generators. Emergency ac power was supplied by a standby inverter

and DC power by a 22-ampere-hour battery. For ground operation, an auxiliary power unit (APU) was located in the left sponson and drove the normal AC generators.

The APU was a small gas turbine engine connected to a right-angle drive gear attached to the accessory section of the main transmission. The accessory section drove the two AC generators, the No. 2 hydraulic pump, and the main transmission lube oil pump. The APU operated at 59,000 RPM, and generated 76 shp in continuous operation. It used fuel from the aircraft fuel tanks.

Two "essentially separate" 3,000-psi hydraulic systems were provided. One system, operating at 5 gallons per minute, powered only the primary side of the flight control servos. The second hydraulic system, operating at 20 gpm, powered the secondary side of the flight control servos, plus all other items that required hydraulic power (landing gear, brakes, turrets, etc.). Both systems were active any time the engine was running. To the maximum extent possible, the hydraulic lines were separated to reduce the chances of losing both systems to battle damage.

### Flight Control System

The primary flight control system included those components required to provide longitudinal (pitch), lateral (roll), directional (yaw), and collective (lift) control of the aircraft. The controls in the pilot station included a cyclic lever for pitch and roll control, a collective lever for lift control, and anti-torque pedals for yaw control. A set of flight controls was also provided at the gunner station; however the gunner cyclic

(above the right console) and collective (on the left) were normally stowed and disconnected from the flight control linkage.

The cyclic lever provided conventional longitudinal (pitch) and lateral (roll) control; moving the cyclic forward-aft resulted in changes in pitch, while left-right movements resulted in roll changes. Pulling the collective lever upward increased the angle-of-attack on all four rotor blades, resulting in increased lift; lowering the collective had the opposite effect. The pilot's collective included an engine speed<sup>4</sup> control grip and a propeller pitch control grip. Engine speed was normally set and locked, and no capability was provided for the gunner to adjust it. The pilot's anti-torque pedals were equipped with toe brakes. Both sets of pedals could be adjusted through a range of about six inches to accommodate pilots of different heights.

Control inputs were transmitted through a mechanical linkage of push-pull rods, levers, bellcranks, torque tubes, and cables to dual hydro-mechanical servo-actuators. In the longitudinal (pitch) and lateral (roll) controls systems, the servo-actuators amplified the input forces and transmitted them to a control gyro located above the main rotor.<sup>5</sup> The forces acting on the gyro caused it to precess (tilt) and change the pitch of the main rotor blades in a cyclic manner. In the collective (lift) control system, the amplified forces from the servo actuators caused an up or down movement of the swashplate and control gyro along the rotor axis, thus causing the main rotor blades to change pitch in a collective manner. Directional (yaw) controls inputs were amplified by a servo-

actuator and transmitted to the anti-torque rotor blades through a mechanical linkage.

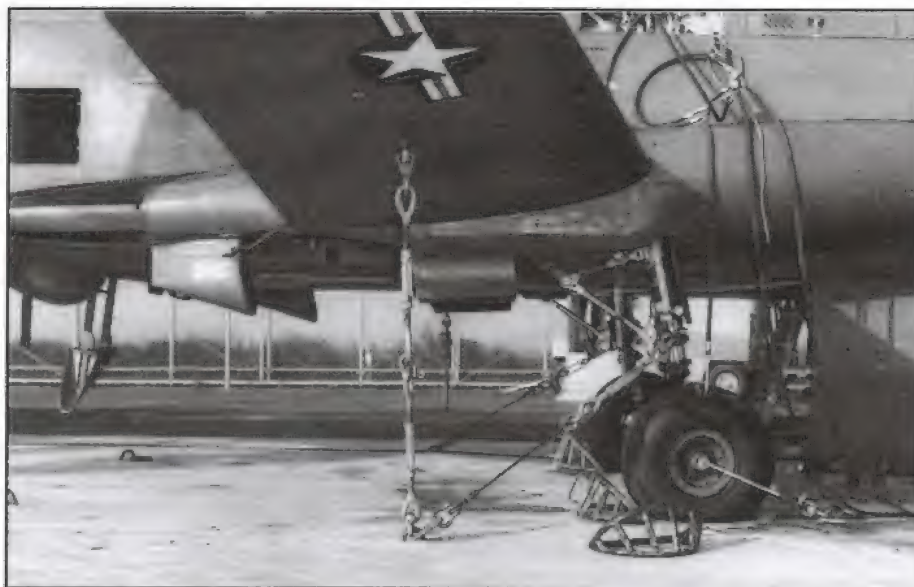
The control gyro served as a stabilizing gyro within the control system, and rotated at the same speed as the main rotor. Pitch links and arms connected the gyro, at its base, to the four main rotor blades. The plane of rotation was displaced when control inputs were applied through the swashplate. Without control inputs, the gyro remained in its own plane of rotation, even when the rotor/airframe was displaced by an external disturbance (wind gust, etc.). Such a displacement, if strong enough, altered the angle between the plane of the gyro rotation, causing the gyro to change the pitch of the main rotor blades in a cyclic manner and returning the main rotor to its original plane of rotation.

### Stability Augmentation

The Cheyenne included two stability augmentation systems, amongst the first helicopter to be so equipped. The yaw axis stability augmentation system (YASAS) provided directional stability of the aircraft in flight by damping out low-frequency yaw oscillations. The system also provided a heading hold function. The lateral control desensitizer system decreased the aircraft tendency to engage in undesirable roll oscillations during some flight maneuvers. Essentially, the desensitizer ignored the first 0.75-inch of cyclic travel in the left-right direction.

### Landing Gear

The landing gear was electrically controlled and hydraulically actuated. The two main landing gear wheels retracted by swinging aft



*The main landing gear. (San Diego Aerospace Museum Collection)*

and up, while the tail wheel retracted straight up into the ventral stabilizer. The main wheels were partially exposed under the sponsons when retracted, although the struts were covered with retractable doors. The main gear wheels contained disk-type brakes, but no anti-skid system was fitted. Landing gear extension and retraction, as well as brake operation, were handled by the No. 2 hydraulic system. A cable release mechanism provided a means to lower the landing gear in the event of hydraulic failure.

Skids could be installed on the main landing gear shock struts to support the aircraft on mud-covered terrain. The installation of the mud skids did not interfere with the normal operation of the landing gear; however, the main landing gear doors and door-actuating linkage had to be removed in order for the gear to retract.

Two cable cutters were installed on the aircraft to prevent entanglement in cables and wires that might be encountered at low altitude. Both cable cutters were mounted aft of

the pilot station, one on the bottom and one on top of the fuselage. Both cutters consisted of a guide assembly and two cutter wheels capable of severing cables and wires with a diameter up to 3/8-inch.

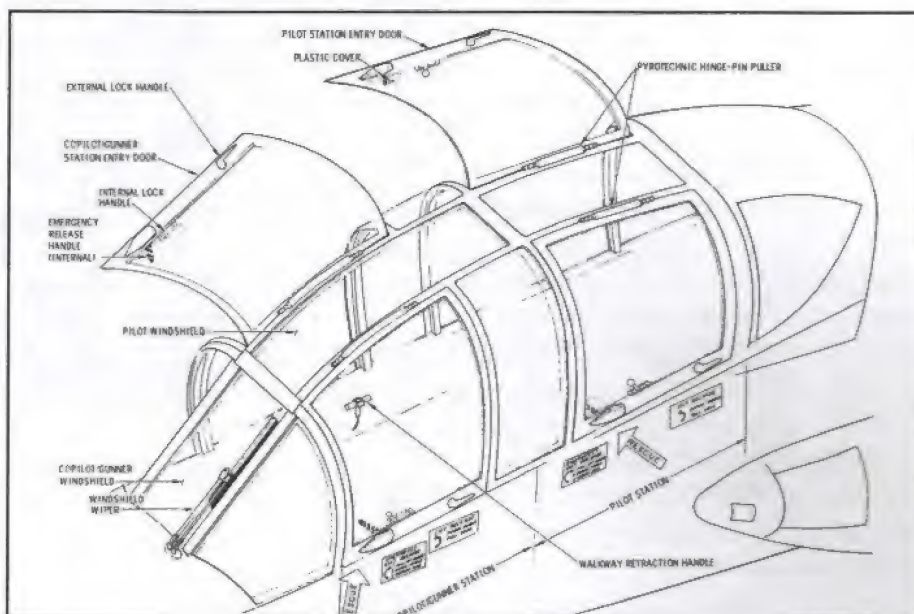
## FLAWS

The fault location and warning system (FLAWS) was a very early attempt at providing enhanced

notification to the flight crew of mechanical problems. FLAWS could provide both visual (caution lights) and aural (tones, or a female voice) warning of system faults and system status. The FLAWS continually monitored the built-in test equipment (BITE) and various system parameters for operation within prescribed limits. When items went outside those limits, lights or aural warnings were presented to the crew.

## Seats, Canopy, and Access

The crewmember seats were equipped with back and seat cushions with crash-load attenuation capability. The seat cushions could be replaced with survival kits, and the back cushions could be replaced with back-pack parachutes as required. Each seat was equipped with a safety belt, crotch belt, shoulder harness, inertia reel, and armor plating to protect from small arms fire. The aft (pilot) seat could be adjusted fore and aft, as well as vertically. The forward (gunner) seat was mounted to the SGS turntable and had only vertical adjustments.



*The late-model side-opening canopy enclosure. (U.S. Army)*

Relief tubes were provided for the pilot and gunner; the pilot's was stowed under the collective, and the gunner's was stowed on the right side of the vertical bulkhead behind the seat. Both vented overboard when used.

The pilot and gunner sat under a canopy composed of aluminum frames and 11 stretched acrylic panels, two windshields, and four doors. The windshields were constructed of laminated glass and plastic, and included electric defrosting and an electric windshield wiper. Rearview mirrors were located on the forward front vertical frame just below the entry door hinge.

Originally, a single-piece sliding canopy door covered the pilot's station. This proved prone to excessive

vibration and was replaced by a left and right door, hinged at the top, similar to those at the gunner's station. The doors were manually opened and closed, and were held open by a telescopic rod.

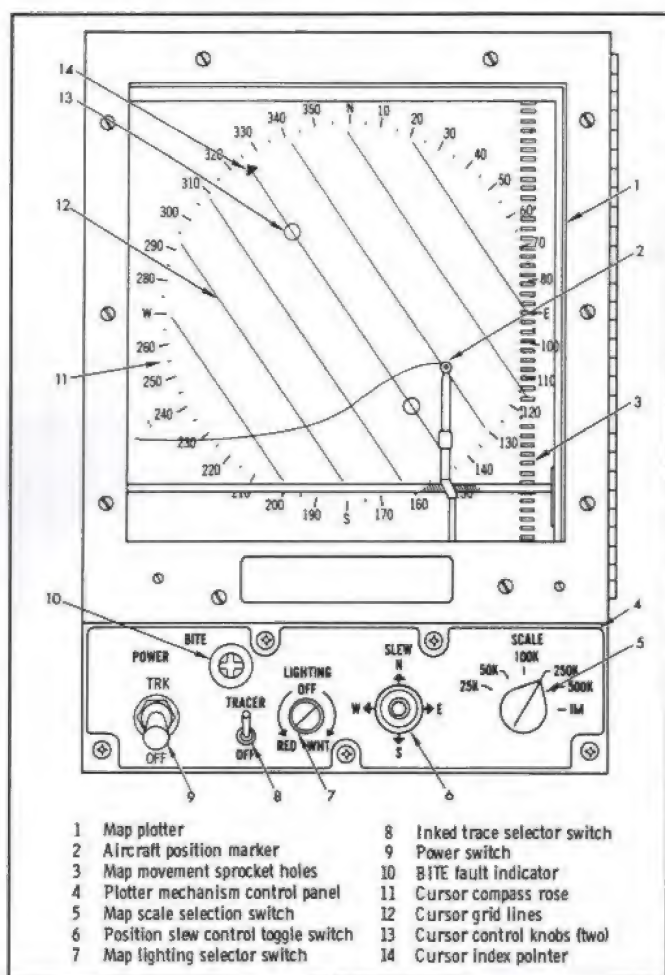
Retractable boarding ladders were installed in the aft end of each sponson. The left boarding ladder could only be extended or retracted manually; the right ladder could be extended or retracted electrically when there was weight on the wheels. A retractable walkway, used to gain access to the crew compartments, was installed on the right side of the fuselage forward of the right sponson and at the same height. It was 10.5 inches wide, 64 inches long, and capable of supporting 600 pounds. The walkway was hinged at the bottom edge

and folded into a well so that it was flush with the fuselage when not in use. The walkway was extended and retracted manually, and the person in the front seat could reach it while seated.

## Avionics

The Cheyenne included the first Integrated Helicopter Avionics System (IHAS) fitted to a helicopter, and one of the first installed on any aircraft. The AH-56A included an electronic fire control system, a communications system, and an advanced navigation system, all interconnected with each other.

The communications system included an intercom, ARC-114 VHF/FM radio, ARC-115 VHF/AM radio, ARC-116 UHF/AM radio, and a



The map plotters were an ingenious solution, given the technology of the day. The display consisted of a transparent cursor disc that covered a tracer assembly and map cassette. Lines were scribed on the cursor disc which equated 10 nm on a 1:1,000,000 scale map. A built-in pen could be used to record the flight path on the map for future reference. (U.S. Army)

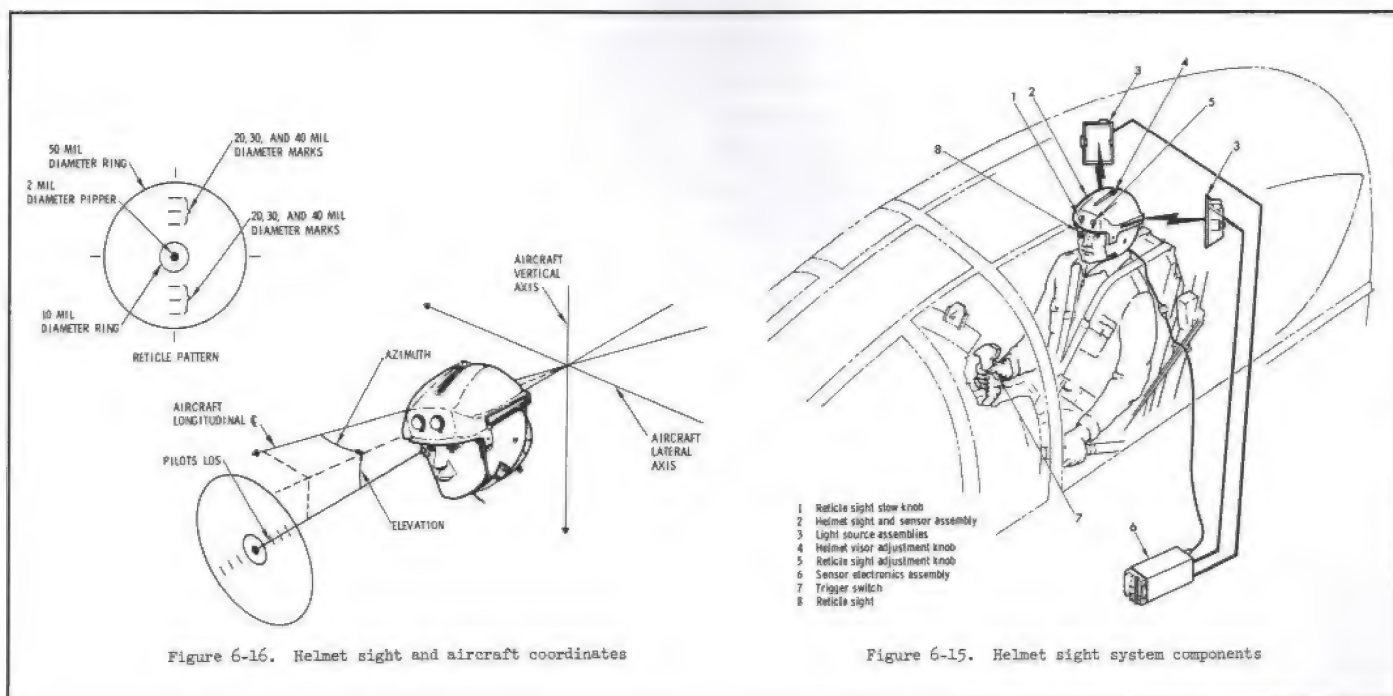


Figure 6-16. Helmet sight and aircraft coordinates

Figure 6-15. Helmet sight system components

*The XM-110 pilot helmet sight system was years ahead of its time, and is only now beginning to become a reality on modern combat aircraft. Reportedly, the system worked well in the Cheyenne. (U.S. Army)*

radio relay system that allowed the Cheyenne to provide limited retransmission of voice signals between other aircraft and ground stations within line-of-sight.

The advanced navigation system included an ASQ-126 Doppler heading attitude reference system (DHARS), air data converter, ARN-82 instrument landing system (ILS), ARN-89 automatic direction finder (ADF), and an APX-72 identification, friend or foe (IFF) equipment. Navigation data could be displayed on several cockpit instruments, as well as the map plotters and computer control screen. The DHARS provided altitude, heading, and attitude information to the flight control and weapons systems.

The AYK-7 computer central complex (CCC) performed all the computations required for navigation, fire control, and flight instrument display. This was a triple-redundant digital computer that used a 2-out-

of-3 voting technique similar to that later used on various fly-by-wire aircraft. The CCC provided an extensive array of navigation displays on the control screen. It could display absolute aircraft position, aircraft position relative to a desired location, range and bearing to a desired location, wind speed and direction, ground speed, time-to-go to a checkpoint, magnetic variation, and the ground coordinates of a sighted target.

The map plotters were considered particularly state-of-the-art at the time. One was installed in each cockpit and presented a direct-view map display that provided navigation information to the crew. The map cassette held 18 feet of six-inch-wide universal transverse mercator (UTM) paper maps prepared in one continuous north-up strip map. As the aircraft progressed along its flight path, the position marker (including a pen) moved in relationship to the aircraft speed

and heading as supplied by the CCC. This gave the crew a graphical presentation of their current position on the paper map, which could be saved for future reference.

### Fire Control System

The AH-56A fire control system was extremely advanced when the aircraft first flew, although technology evolves rapidly and the system was somewhat outdated by the time the program was cancelled. The fire control system allowed either crewmember to fire any weapon, although it was optimized for the gunner using the SGS. There were three primary sighting systems installed on the Cheyenne.

**Pilot Helmet Sight System:** The XM-110 helmet sight system permitted the pilot to align the nose turret, belly turret, or SGS with a selected target. The system consisted of a helmet sight that was mounted to the pilot's helmet, two

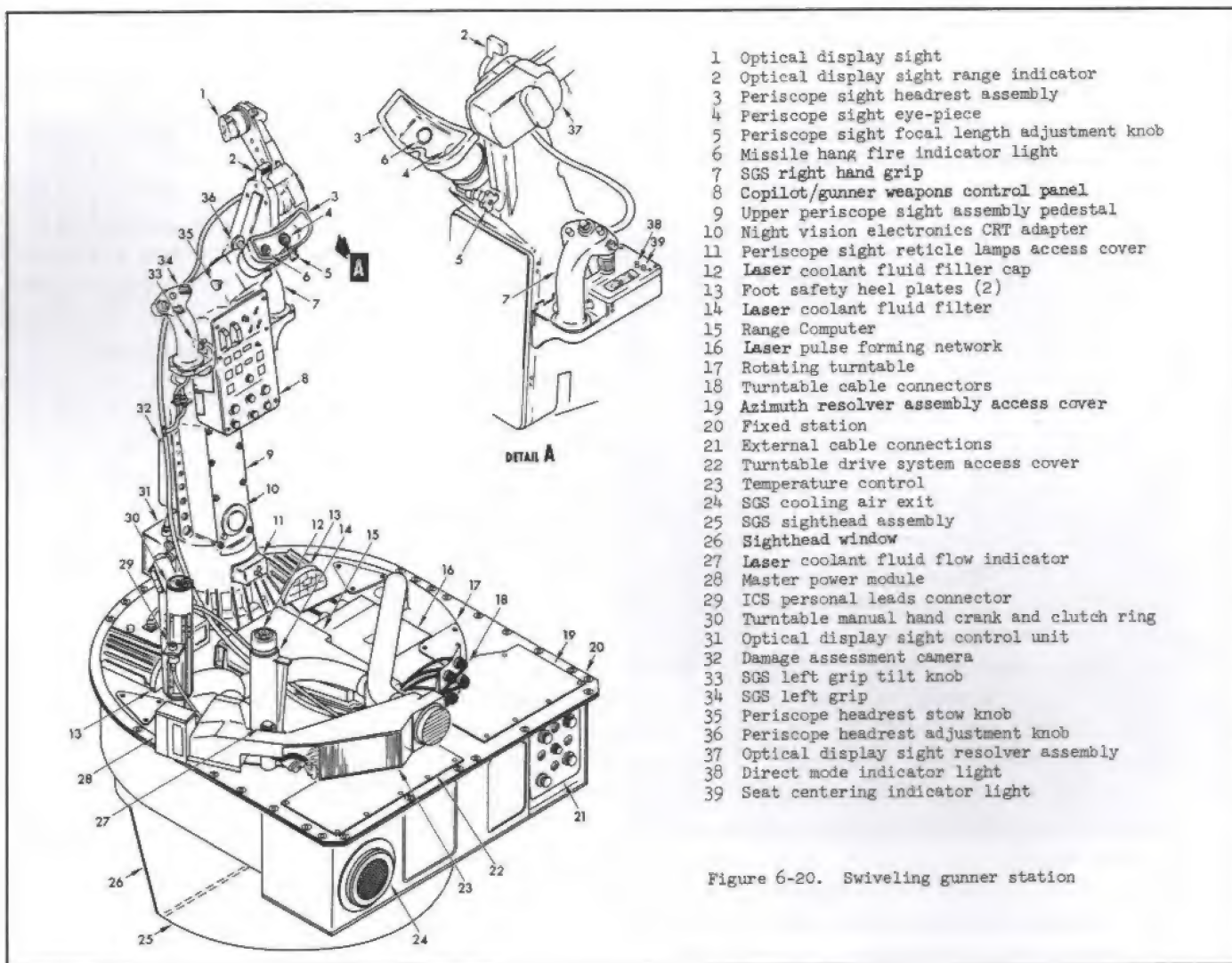
light sources, and a sensor assembly. The operation of the sight was based upon a "line in space" as a reference for the pilot's head movements. Changes in the angular relation between the pilot's line of sight through the reticle and the reference line were measured by the sensor assemblies and sent to the computer central complex.

**Pilot Direct Sight System:** The XM-114 direct sight was a fixed sight mounted on the pilot's glare shield that was used primarily for firing rockets directly ahead of the

aircraft. The sight provided an optical sighting reference for forward firing weapons, and also for bore-sighting the pilot's helmet sight. The sighting reference consisted of a 50-mil-diameter reticle image, a 2-mil-diameter pipper, and had marks representing 20, 30, and 40-mil-diameter circles above and below the pipper. The reticle image was projected on a combining glass display, much like a modern heads-up display. This sight could also be used to fire either turret, but the turret had to be locked in the dead-ahead position.

**Swiveling Gunner Station:** The XM-112 swiveling gunner station (SGS) was equipped with a wide-angle optical display sight and an adjustable-magnification periscope sight that had a view of nearly the entire hemisphere below the aircraft. The complete station, including the gunner's seat, could rotate in azimuth, and was stabilized to allow the gunner to concentrate on a given target independent of most aircraft motion.

The display and seat were mounted on a turntable supported by 240



*The XM-112 swiveling gunner station was like nothing before, or since. The gunner sat on a platform that could swivel to follow targets as the aircraft flew by them. Whichever turret the gunner was controlling followed the seat's motions. (U.S. Army)*

plastic ball bearings. Two electric drive motors rotated the turntable at a maximum rate of 100° per second. If one motor failed, the turntable could still be rotated at 50° per second. In order to rotate the turntable, the gunner had to place his feet on two safety heelplates and depress them. A handcrank was provided to rotate the turntable in the event both electric motors failed, but this was primarily meant to return to the straight forward position.

The gyro-stabilized sight was viewed by the gunner using a periscope, and had three possible magnifications: 1.5X, 4.2X, and 12X. The platform for the sight also incorporated a laser rangefinder, an AAS-25 infrared sensor, and TOW guidance equipment.

**Damage Assessment Camera:** A 16-mm motion picture camera was located on the upper periscope sight assembly pedestal that operated whenever a weapon was being fired.

## Armament

The Cheyenne was equipped with provisions for two rotating turrets, one in the nose and one under the fuselage, and six external hard-points, two under each wing and one under each fuselage sponson. The nose turret could alternately contain either a single 40-mm grenade launcher or a single 7.62-mm minigun. The belly turret contained a single 30-mm cannon. A large ammunition magazine compartment was located just aft of the pilot station and fed both turrets.

**XM-51 Fire System:** The XM-51 fire system consisted of a XM-129 40-mm grenade launcher, a nose

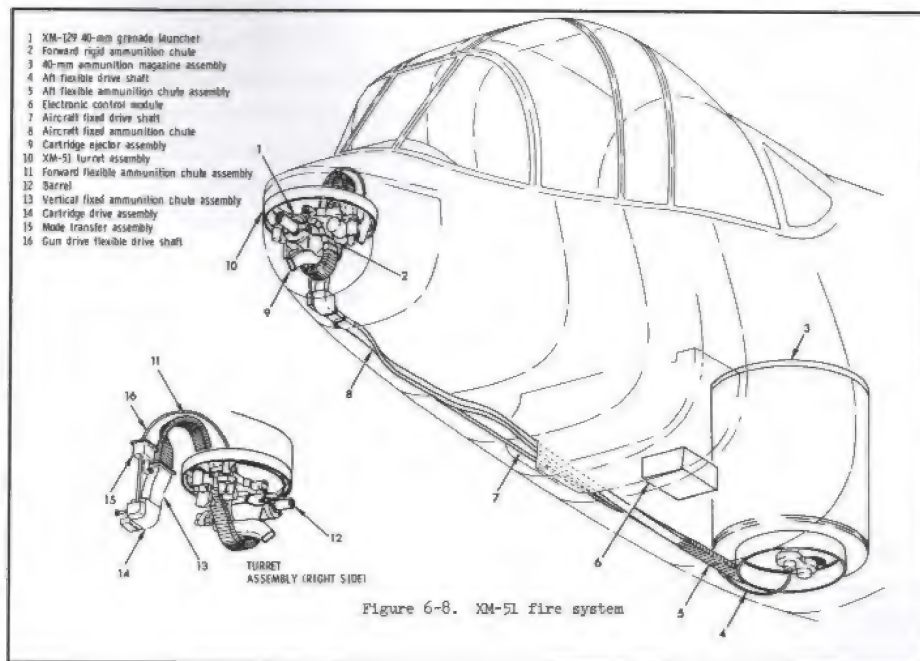


Figure 6-8. XM-51 fire system

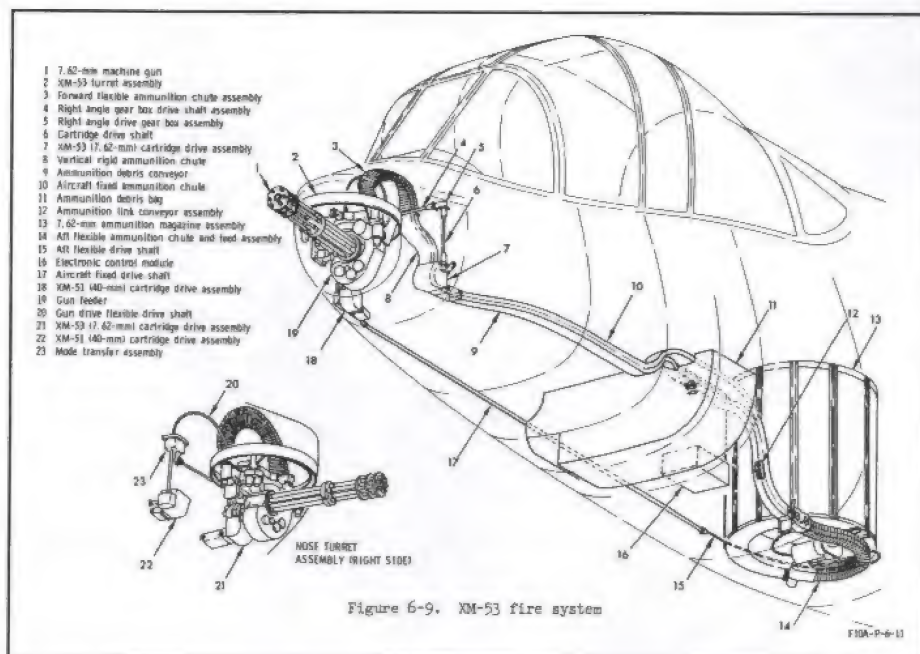


Figure 6-9. XM-53 fire system

The XM-51 40-mm grenade launcher and the XM-53 7.62-mm minigun fire systems were interchangeable. However, late in the program the Army decided to drop the minigun as an option. Note the different feed paths taken by ammunition for the two systems; this made it fairly difficult to switch between the systems in the field. (U.S. Army)

turret assembly, ammunition magazine assembly, and various drive mechanisms and fire control modules. The grenade launcher was an air-cooled, mechanically-driven weapon capable of firing 350 anti-personnel fragmentation projectiles

per minute. The XM-51 turret was capable of rotating 100° either side of the centerline, and elevating +18/-70° from the aircraft waterline. The 780 rounds of ammunition was stored in the forward part of the magazine compartment. A series of

fixed and flexible belts brought the ammunition from the magazine along the lower fuselage to the turret. Both the gun and feed mechanisms were electrically driven.

**XM-53 Fire System:** The XM-53 fire system consisted of a XM-196 7.62-mm six-barrel minigun, a nose turret assembly, ammunition magazine assembly, and various drive mechanisms and fire control modules. The minigun was capable of delivering suppressive fire at selected rates of 750, 1,500, 3,000, or 6,000 rounds per minute. Externally, the XM-53 turret was similar to the XM-51, but

used a different mounting cradle internally to support the minigun. The XM-53 turret was capable of rotating 100° either side of the centerline, and elevating +18/-70° from the aircraft waterline. Up to 11,750 rounds of 7.62-mm ammunition could be stored in the forward part of the magazine compartment. A series of fixed and flexible belts brought the ammunition from the magazine along the lower fuselage to the turret, but it should be noted that a different path was used for the 7.62-mm ammunition than for the 40-mm ammunition. This resulted in it being rather difficult to

change the aircraft configuration from one turret to the other, and is possibly the reason that the minigun was deleted from the final production configuration. Empty cases were returned to an ammunition debris bay instead of being ejected overboard.

**XM-52 Fire System:** The XM-52 fire system consisted of an XM-140 30-mm automatic gun, a belly turret assembly, ammunition feed and storage assembly, and a fire control module. The XM-140 30-mm automatic gun was an air-cooled, lightweight, electrically-driven, percussion-fired weapon capable of delivering fragmentation-shaped charges at a rate of 450 rounds per minute. The XM-52 turret assembly was located on the bottom of the fuselage slightly aft of the pilot station. The turret was capable of rotating 200° either side of the centerline, and elevating +26/-60° from the aircraft waterline. There were interlocks that prevented the gun from firing if it was pointed at any part of the aircraft. The 2,010 rounds of 30-mm ammunition was stored in a magazine approximately 40 inches long and 39 inches in diameter located in the rear of the magazine compartment. The feed mechanism was powered by a 2.5-hp electric motor.

**External Armament System:** There were six external hard-points; two under each wing and one under each sponson. All six contained Aero 65A-1 bomb racks and were capable of carrying a 2,000 pound load. The rack hooks were spaced 14-inches apart, and could be equipped with Aero 1-A adapters that provided 30-inch hook spacing. A maximum of two 3-missile BGM-71 TOW pods could be carried on the inner wing stations. Alter-

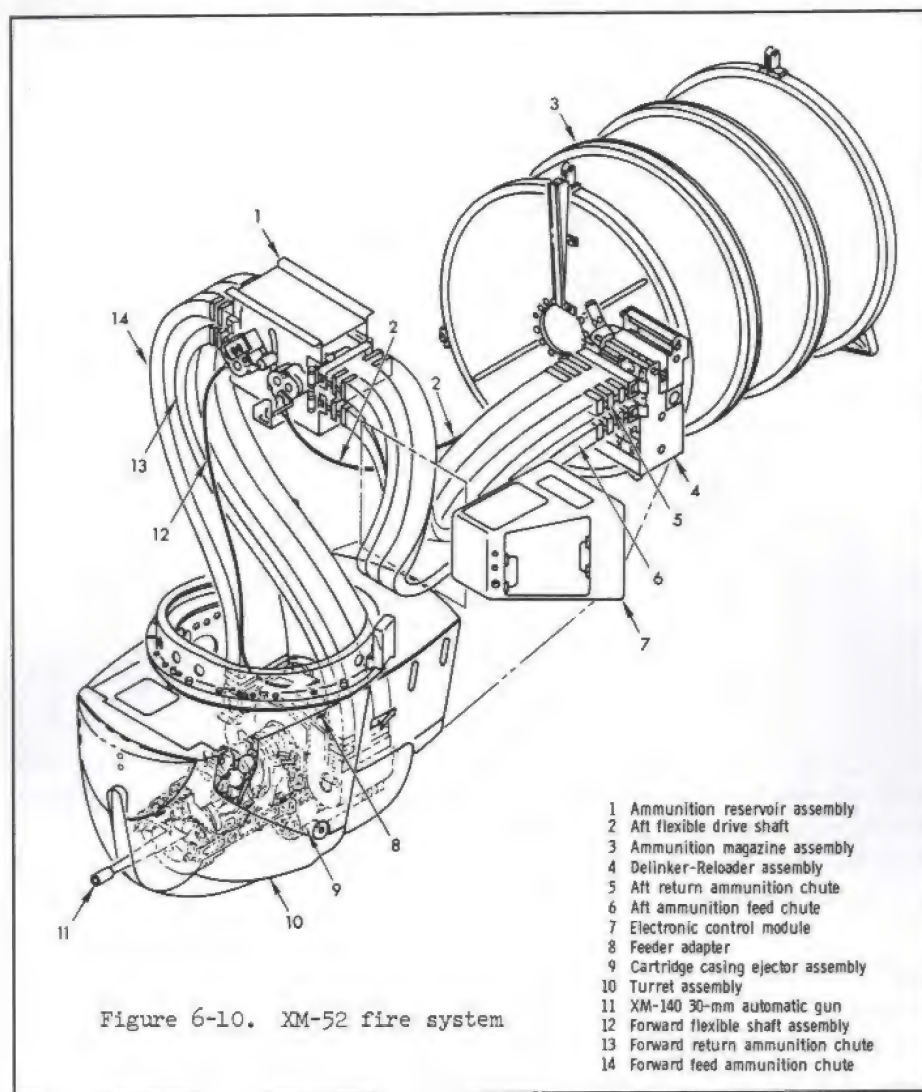
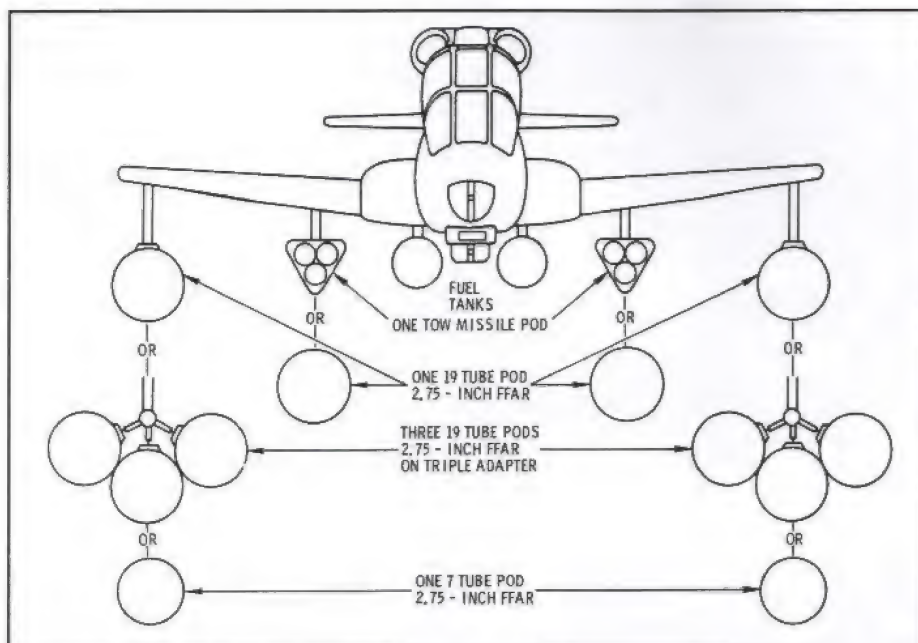


Figure 6-10. XM-52 fire system

The XM-52 fire system was located in the belly turret and consisted of a 30-mm cannon capable of firing 450 rounds per minute. (U. S. Army)



*The weapons carriage illustration from the flight manual. Only fuel tanks were cleared for carriage on the sponson pylons, and no photos have been found that indicate this ever occurred. The inboard pylons normally carried three-tube TOW missile launchers, but could carry single 2.75-inch FFAR pods also. The outer pylons were more versatile. All four wing pylons could also carry fuel tanks for ferry missions. (U. S. Army)*

nately, up to 152 2.75-inch folding fin aircraft rockets (FFAR) could be carried using a 19-tube launcher on each inboard pylon and three 19-tube launchers on triple adapter racks (TAR) on the outboard pylons. The four wing pylons could each carry a 450-gallon external fuel tank. Each of the sponson pylons was plumbed for a 300-gallon fuel tank. On ferry missions, because of weight limitations, the maximum fuel load was four 450-gallon tanks, and one 300-gallon tank. The other sponson pylon would either be empty, or would carry a travel pod (for the crew's clothes).

Interestingly, the six pylons were not interchangeable due to the

changing wing sweep and dihedral. They were, however, all of similar construction consisting of a one-piece forged aluminum strongback with machined aluminum mounting pads. Each pylon contained four adjustable sway braces to constrain loaded stores. The TARs were designed to allow triple-loading of stores, and could only be used on the outer wing pylons. The only stores cleared for use on the TAR during the test program were XM-157 7-tube and XM-159 19-tube FFAR rocket pods.

**FFARs:** The 2.75-inch FFAR rockets were fin-stabilized unguided rockets consisting of a 48-inch long rocket motor with folding fins and

a warhead. When retracted, the folding fins were the same diameter as the rocket body. The fins automatically deployed as the rocket left the launch tube. The rockets could be carried in either 7-tube XM-157 or 19-tube XM-159 launchers in any combination as long as the load was symmetrical. The reusable launchers were constructed of aluminum and had non-reusable fiberglass fairings front and rear to reduce drag. The fairings were blown off the launcher when the rockets were fired. The launchers used 14-inch lugs and could be parent-mounted directly to the Aero 65A-1 bomb rack, or to a TAR.

**BGM-71 TOW Missile System:** The TOW anti-tank missile was a tube-launched optically-tracked wire-guided missile. It required that the Cheyenne keep the target centered in the TOW sight for the entire flight of the missile. Steering corrections were sent to the missile through two thin trailing wires that connected to the TOW launcher. The wires were cut after a prescribed time delay. The wires were also fairly fragile, and could not be dragged across obstacles such as power lines, trees, etc. On the Cheyenne, the missiles were carried in a reusable 3-missile pod that was constructed from sheet aluminum. The pod contained three sets of rails that allowed TOW missile launchers to be installed. The missile was preassembled in its launcher at the factory and was handled as a single unit in the field. Each TOW missile was 44 inches long and weighed 43 pounds.

<sup>1</sup> Unless otherwise noted, all descriptions in this chapter come from: *Operators Manual, Helicopter, Attack, AH-56A (Lockheed)*, 66-8831 (1006), POMM 55-1520-222-10, July 1971. <sup>2</sup> The T64-GE-16 version was awarded an FAA type certificate on 25 March 1965. The engine was expected to be used in Lockheed helicopters and the German VFW-Fokker VC400 tilt-wing transport. Other versions of the T64 power the H53-series helicopters, the XC-142A tilt-wing transport, Japanese Shin Meiwa PS-1 flying boat, Kawasaki P-2J patrol aircraft, de Havilland of Canada DHC-5 Buffalo, and the Fiat G.222 medium transport.

<sup>3</sup> Traditional for the United States. Russian rotors traditionally rotate clockwise. European rotors are uncommitted and may rotate in either direction. <sup>4</sup> Actually, it set the gas generator (Ng) speed. <sup>5</sup> This description does not apply to the seventh aircraft when fitted with the AMCS. See chapter 5 for a description of the AMCS.



*Looking much like a production aircraft would have, Ship #1006 (66-8831) has a full complement of turrets, sensors, and weapons pods. (San Diego Aerospace Museum Collection)*

*A fully-equipped targeting and tracking system on Ship #1006 (66-8831) on 31*

*March 1972. This is the sensor suite that production aircraft would have used, and includes TOW guidance components, infrared sensors, and laser range-finding equipment. The concept of using lasers to designate targets for "smart" weapons was still in its infancy, but would eventually have been used by the AH-56A Cheyenne. (Lockheed)*



*The ninth Cheyenne (1009; 66-8834) during ground tests on 24 November 1968. Note that there is no orange strip around the fuselage – something normally apparent in most photographs of this aircraft. (San Diego Aerospace Museum Collection)*

# FLIGHT TEST DUTIES

## WHAT EACH CHEYENNE DID

During the test program, each Cheyenne was assigned a particular task. Highlights of how they were utilized, and their final disposition, is as follows:

—	(1000)	Static Test Article. Never Flew. Remains of the airframe are at the Aberdeen Proving Grounds, Maryland.
66-8826	(1001)	Ground Test Vehicle (GTV). Never flew. Tested in Fort Cheyenne. Used for various ground, engine, and rotor tests. Used for ballistic survivability testing at Rock Island Arsenal. At the Aberdeen Proving Grounds, Maryland, in April 1982.
66-8827	(1002)	Flight Development Vehicle (FDV). First aircraft to fly. Flew at Van Nuys and Oxnard, California. Used for initial flying qualities and aerodynamic tests. No weapons system. Currently at Fort Polk, Louisiana.
66-8828	(1003)	Flight Development Vehicle (FDV). Flew at Van Nuys and Oxnard, California. Envelope expansion aircraft. Crashed on 12 March 1969, killing Dave Beil.
66-8829	(1004)	Weapons Integration Vehicle. Tested at Portrero, California. Scrapped.
66-8830	(1005)	Avionics Integration/Development Vehicle. Flew at Van Nuys and Oxnard, California. First aircraft equipped with the complete Integrated Helicopter Avionics System (IHAS). Currently in storage (with incorrect serial number 68866) at the Army Aviation Museum at Fort Rucker, Alabama.
66-8831	(1006)	Weapons Test Vehicle. Used for Swiveling Gunner Station (SGS) and Pilot Helmet Sight (PHS) testing. Flew at Van Nuys and Oxnard, California. Conducted high-altitude testing at Bishop, California. Participated in Cheyenne-Cobra flyoff at Hunter-Liggett, California. Weapons testing at Yuma Proving Grounds, Arizona. Was painted in three-tone tactical camouflage at the end of the program. Currently at the Don F. Pratt Museum at Fort Campbell, Kentucky.
66-8832	(1007)	Missile and night vision development vehicle. Used for TOW missile tests at Yuma Proving Grounds, Arizona. Only aircraft equipped with the Advanced Mechanical Control System (AMCS). Recorded fastest flight of the program (240 knots). Made last flight of program. Was stored in flyable condition at Edwards AFB after program ended. Retired to the Army Transportation Museum at Fort Eustis, Virginia. Later moved to Fort Rucker, Alabama, and put on display at the Army Aviation Museum.
66-8833	(1008)	Avionics Laboratory Integration Vehicle. Never Flew. Used at Van Nuys, California for electronic systems integration. Retired to Fort Monmouth, New Jersey. At the Aberdeen Proving Grounds in April 1982.
66-8834	(1009)	Flight Development Vehicle (FDV), replacing #1003 as the envelope expansion aircraft. After the crash of #1003, a Lockheed F-104 ejection seat was installed in the front cockpit. Was stored in flyable condition at Edwards AFB after program ended. Scrapped.
66-8835	(1010)	Complete Systems Vehicle. Performed cold-weather/icing tests in Canada. Was equipped with station-keeping radar, terrain-following radar, and automatic flight control system. Only aircraft to have Indian Head art on the forward fuselage. Destroyed in the Ames wind tunnel on 17 September 1969.

# SURVIVORS

## THE REMAINING CHEYENNES



*The static test article (1000) at Aberdeen Proving Grounds, Maryland, during April 1982. (Stan Piet)*



*The second Cheyenne (1002; 66-8827) on display at Fort Polk, Louisiana, in June 1999. (Ron Girouard)*



*Ship #1005 (66-8830) in storage at Army Aviation Museum at Fort Rucker, Alabama, in May 1999. The aircraft currently wears an incorrect serial number (68866). (Tony Landis)*

*The weapons test vehicle (1006; 66-8831) on display at the Don F. Pratt Museum at Fort Campbell, Kentucky, in August 1999. (Heidi Page)*



*The seventh Cheynne (1007; 66-8831) at the Army Transportation Museum at Fort Eustis, Virginia, in May 1987 prior to being moved to Fort Rucker.*



*Ship 1007 (66-8831) sitting in front of the Army Aviation Museum at Fort Rucker, Alabama in May 1999. Note the AMCS rotor system. (Tony Landis)*

*Ship #1008 (foreground) and Ship #1001 (background) in storage at Aberdeen Proving Grounds during April 1982. (Stan Piet)*



# SIGNIFICANT DATES

## KEY DATES IN THE HISTORY OF THE AH-56A CHEYENNE

**13 November 1907:** Frenchman Paul Cornu makes the first successful helicopter flight.

**Early 1920s:** Juan de la Cierva begins developing autogyros.

**13 May 1940:** Igor Sikorsky makes the first untethered flight in the VS-300.

**2 November 1959:** The Lockheed CL-475 makes its first flight.

**Early 1960:** Bell begins development of the Model 204 (UH-1) "Huey."

**Early 1962:** The first UH-1s arrive in Vietnam.

**2 November 1962:** The Lockheed XH-51A makes its maiden flight.

**1963-1964:** The Vertol CH-47 Chinook begins operations in Vietnam.

**27 March 1963:** Secretary of the Army Cyrus R. Vance rejects the preliminary specification for an armed helicopter.

**1 August 1964:** The U. S. Army releases the Request for Proposal for the Advanced Aerial Fires Support System (AAFSS).

**7 September 1965:** The Bell Model 209 (future AH-1G) makes its first flight.

*Three Army P-51D Mustangs acted as chase aircraft for the Cheyenne at various times during its test program. (Matt Graham Collection)*

**4 April 1966:** The Army orders its first AH-1 HueyCobras.

**23 November 1964:** The first round of the AAFSS competition ends.

**9 March 1965:** Sikorsky and Lockheed are selected to continue AAFSS studies.

**10 April 1965:** The XH-51A Compound makes its first flight.

**11 August 1965:** Final AAFSS proposals are submitted.

**3 November 1965:** Lockheed is declared the winner of the AAFSS competition.

**23 March 1966:** Lockheed receives contract to build ten AH-56As.

**16 April 1967:** The first AH-56A is rolled out.

**21 September 1967:** The first AH-56A makes its maiden flight.

**12 December 1967:** The Cheyenne is unveiled to the public.

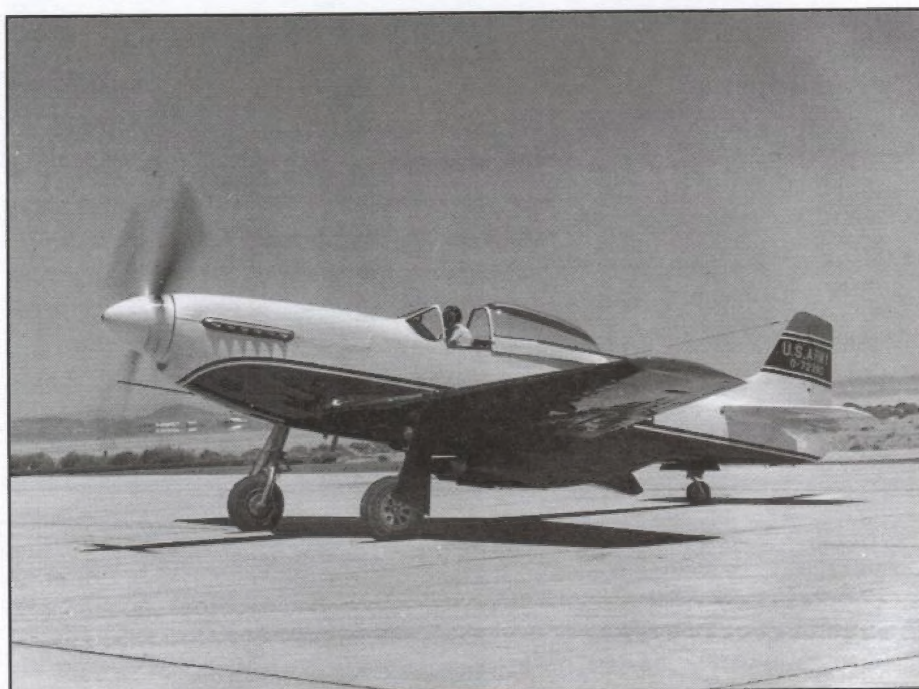
**12 March 1969:** Test pilot Dave Beil is killed in the crash of the third Cheyenne.

**19 May 1969:** The Army cancels Cheyenne production; development continues.

**17 September 1969:** The tenth Cheyenne is destroyed in an accident in a NASA wind tunnel.

**30 January-23 December 1971:** The Army Preliminary Evaluations are conducted at Yuma Proving Grounds.

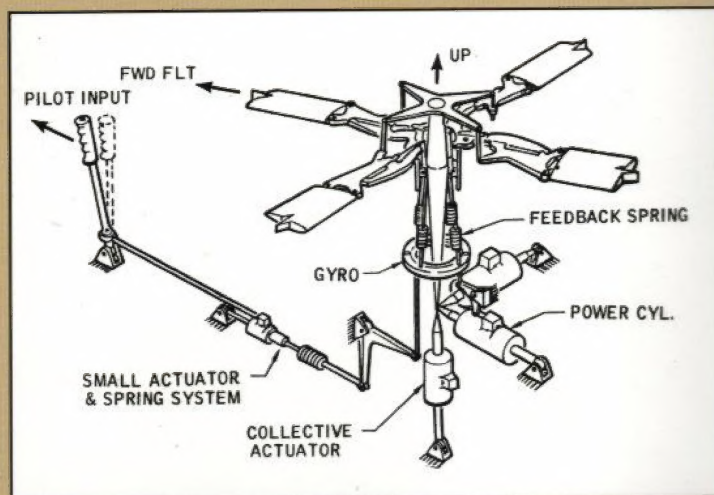
**9 August 1972:** The Army cancels the Cheyenne in its entirety.





THE CHEYENNE HAD BEEN CONCEIVED AS A HIGH-SPEED ESCORT FOR TROOP HELICOPTERS, BUT THE AIRCRAFT THAT LOCKHEED WAS BUILDING WAS CAPABLE OF MUCH MORE. ARMY COMMANDERS BEGAN DEVELOPING CONCEPTS THAT USED THE CHEYENNE IN DIRECT FIRE-SUPPORT ROLES. THIS WAS UNDERSTANDABLE. MOST CLOSE-AIR SUPPORT WAS PROVIDED BY FIXED-WING AIRCRAFT THAT COULD NOT FLY LOW AND SLOW ENOUGH TO ENGAGE SOME OF THE TARGETS THE FIELD COMMANDERS NEEDED DESTROYED. THE AIRCRAFT ALSO HAD TO LEAVE THE BATTLEFIELD FREQUENTLY TO RETURN TO A FRIENDLY BASE TO REFUEL AND REARM. THE BELL AH-1 COBRA WAS PROVING TO BE A VALUABLE ASSET, BUT IT DID NOT CARRY ENOUGH WEAPONS, LACKED A SOPHISTICATED FIRE CONTROL SYSTEM, AND HAD A LIMITED RANGE.

THE CHEYENNE COULD CHANGE ALL OF THIS. WITH A MISSION ENDURANCE OF 2.5 HOURS ON STATION (PLUS 30 MINUTES TRANSIT TIME), THE AH-56A COULD PROVIDE SUPPORT FOR TROOPS THROUGHOUT A BATTLE. AT 2,000 FEET ELEVATION ON AN 80°F DAY THE CHEYENNE COULD CARRY 2,100 POUNDS OF ORDNANCE – USUALLY LISTED AS 2,010 ROUNDS OF 30-MM AMMUNITION, 780 ROUNDS OF 40-MM AMMUNITION, SIX BGM-71 TOW ANTI-TANK MISSILES, AND 38 2.75-INCH ROCKETS. EVEN IN THE HEAT AND HUMIDITY OF SOUTHEAST A THIS WEAPONS LOAD WOULD ONLY BE REDUCED BY THE TOWS.

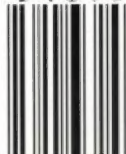


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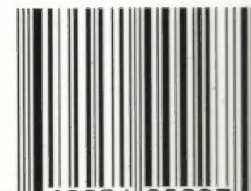
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